

Working Remotely and the Supply-side Impact of Covid-19*

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MAY 31 2020

Abstract

We analyze the supply-side disruptions associated with Covid-19 across firms and workers. To do so, we exploit differences in the ability of workers across industries to work remotely using data from the American Time Use Survey (ATUS). We find that sectors in which a higher fraction of the workforce is not able to work remotely experienced significantly greater declines in employment, significantly more reductions in expected revenue growth, worse stock market performance, and higher expected likelihood of default. In terms of individual employment outcomes, lower-paid workers, especially female workers with young children, were significantly more affected by these disruptions. Last, we combine these ex-ante heterogeneous industry exposures with daily financial market data to create a stock return portfolio that most closely replicates the supply-side disruptions resulting from the pandemic.

*We thank Carola Frydman for helpful comments and discussions. We are grateful to Nathaniel Barlow and Jorge Colmenares-Miralles for excellent research assistance and Evan Soltas, SafeGraph, and the Risk Management Institute (RMI) of the National University of Singapore for sharing their data.

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The Covid-19 pandemic of 2020 has led to severe disruptions to the supply-side of the world economy as entire sectors shut down. In the first quarter of 2020, US gross domestic output fell by 4.8 percent in annualized terms, a decline not seen since the Great Recession. This drop underestimates the full economic impact of the pandemic, since the severity of the crisis became fully apparent to the public and private sector only in the last few weeks of March. Moreover, the effect has been highly asymmetric: restaurants, entertainment, and travel services suffered significantly more than food or technology services. Naturally, these declines reflect not only the supply side disruptions due to the effect of the lockdown, but also demand-side factors, including the collapse of global consumer demand and expectations of future government policy. This confluence of adverse forces obscures the direct effects of the supply-side disruptions of the pandemic.

Our goal is to isolate the supply side effects from other forces. Our starting point is that industries in which a higher fraction of the labor force can work remotely are likely to experience less severe disruptions in their business operations. We build on existing work and construct a metric of industry exposure to the lockdowns using information on the share of the workforce that can work from home (Dingel and Neiman, 2020; Alon, Doepke, Olmstead-Rumsey, and Tertilt, 2020). Specifically, we follow Alon et al. (2020) and exploit data from the American Time Use Survey (ATUS) in 2017 and 2018, which survey workers regarding the extent to which they are able to and have historically had experience working remotely. As noted by Alon et al. (2020), occupations vary immensely by whether people report they are able to tele-commute—ranging from 3% for transportation and material moving to 78% for computer programmers. We then aggregate these survey responses to build measures of exposure across industries and groups of workers.

In brief, our assumption is that whether firms are able to effectively continue their business operations during the pandemic depends on whether workers can perform their tasks remotely. As such, our measure of supply side disruption for a given industry, termed ‘Covid-19 work exposure’, is equal to one minus the fraction of workers that have tele-commuted – more specifically, the fraction that have ever worked days only from home – in each industry. Importantly, there is considerable dispersion in our exposure measure across industries. For example, software publishers (NAICS 5112) has an exposure of just 0.38, since much of the production work can be done remotely; by contrast, meat production (NAICS 3116) or general merchandise stores (NAICS 4523) have an exposure close to one, since most of the employees cannot perform their work remotely.

In addition, government restrictions also played a role in firms’ ability to continue operations. Specifically, local governments typically deemed certain industries as ‘critical’,

namely those that provide ‘essential infrastructure’. Thus, we also manually classified some industries as ‘essential’. Since the definition of essential industries varies greatly across states, we aimed to be conservative, classifying as essential industries related to the production and sale of food and beverages; utilities; pharmacies; transportation; waste collection and disposal; and some healthcare and financial services. Data on foot-traffic from *SafeGraph* validate our construction: establishments in industries deemed critical experienced significantly smaller declines in traffic than establishments in non-critical industries, which stands in stark contrast to nearly identical trends in foot traffic in January-February 2020.

Armed with a measure of industry exposure to these supply side disruptions allows us to isolate these effects from other economic forces that would otherwise affect these sets of firms symmetrically. Our summary finding is that these supply-side disruptions are economically large. Though our findings suggest that the largest disruptions are expected to be concentrated in 2020Q2, financial analysts anticipate these disruptions to persist in the medium term, albeit significantly muted.

Our first set of results concern employment outcomes. We find that sectors with a larger fraction of workers who cannot work remotely—higher Covid-19 work exposure—experienced significantly larger declines in employment than sectors where more of the workforce can perform tasks remotely. The differences are economically sizeable: a one-standard deviation increase in our Covid-19 work exposure measure is associated with approximately a 10 percent larger decline in employment; the differences among sectors is starker when we restrict the sample to non-critical industries (21 percent). We also find some evidence for heterogeneous effects across workers. Specifically, a given increase in our Covid-19 work exposure measure is associated with a somewhat greater increase in the probability of non-employment for women and lower-earning workers. Among all affected groups, we find that the employment status of female workers with young children and without a college degree is most sensitive: in the cross-section of workers, a one-standard deviation increase in our Covid-19 work exposure measure is associated with a 15 percent probability of non-employment for these workers, which is more than three times the magnitude of the average probability of non-employment (4.5 percent).

Our second set of results focuses on firm outcomes. Given the delays in the availability of real data on firm outcomes, we focus on a set of forward looking variables that capture future expectations. That is, we focus on the revisions in analyst forecasts of expected revenue growth; the stock market performance of publicly traded firms; and the expected probability of default. We find that firms in sectors that are more likely to experience work disruptions also fare significantly worse during the 2020 pandemic: a one-standard deviation increase in

our Covid-19 exposure metric is associated with a 7.4 percent decline in analysts’ revenue forecasts for Q2; a 0.26 percentage point increase in the probability of default over the next 6 months; and a 6.7 percent decline in stock market performance to date. These magnitudes account for a significant share of cross-industry differences in outcomes during this period. Last, while financial analysts expect the worst effects to be short-lived, our work exposure variable is still a significant predictor of differences in expected revenue growth over the next two years—though magnitudes are significantly muted.

In the last part of the paper we use some of these forward-looking variables to construct a real-time indicator of supply-side disruptions. In particular, we use daily data on stock returns to construct a portfolio that is maximally exposed to the Covid-19 work disruption using the methodology of [Fama and MacBeth \(1973\)](#). The resulting ‘Covid-19’ factor has a long-short portfolio interpretation. It overweighs industries whose workers cannot work remotely, and underweighs industries whose workers can perform their tasks from home. As of May 15 2020, this portfolio had lost roughly 50 percent of its value since the beginning of the year—compared to 10 percent for the broad market index. Naturally, reversing this investment strategy would deliver a portfolio that could significantly hedge future covid-19 related uncertainty.

In sum, our work contributes to the voluminous economics literature that has emerged in response to the pandemic. The key differentiator of our work is its focus on isolating the supply side disruptions associated with Covid-19. By contrast, existing work has focused on the overall response of the economy during this period.¹ How firms respond during the pandemic is a function of both the underlying supply-side disruptions (our focus) but also firms’ exposures to a decline in consumer demand as a result of expected income losses and increase in uncertainty. Our goal is to isolate the former rather the latter channel. In this respect, our work is closer to [Bonadio, Huo, Levchenko, and Pandalai-Nayar \(2020\)](#) who focus on the role of global supply chains; or [Hassan, Hollander, van Lent, and Tahoun \(2020\)](#) who identify differences in firms’ exposure based on the transcript of analyst calls.

Last, our work bears comparison to recent work by [Dingel and Neiman \(2020\)](#) and [Alon et al. \(2020\)](#). [Dingel and Neiman \(2020\)](#) also construct a measure of the ability to work from home, but they do so by inferring the feasibility of telecommuting from task descriptions in

¹Recent work examines the response of employment ([Coibion, Gorodnichenko, and Weber, 2020b](#); [Cajner, Crane, Decker, Grigsby, Hamins-Puertolas, Hurst, Kurz, and Yildirmaz, 2020](#); [Campello, Kankanhalli, and Muthukrishnan, 2020](#); [Borjas and Cassidy, 2020](#); [Fairlie, Couch, and Xu, 2020](#)); firm revenue ([Barrero, Bloom, and Davis, 2020](#); [Landier and Thesmar, 2020](#)); firm closures ([Bartik, Bertrand, Cullen, Glaeser, Luca, and Stanton, 2020](#)); stock market performance ([Ding, Levine, Lin, and Xie, 2020](#)); or consumer spending [Baker, Farrokhnia, Meyer, Pagel, and Yannelis \(2020\)](#); [Coibion, Gorodnichenko, and Weber \(2020a\)](#) during this period.

the ONET survey. Like us, [Alon et al. \(2020\)](#) construct a measure based on workers’ answers to the American Time Use Survey (ATUS). Though the details of the construction differ, the main idea is similar. What differentiates our work however from these papers is that we are focusing in the ability of these measures to predict differences in worker and firm outcomes during the pandemic. By contrast, [Dingel and Neiman \(2020\)](#) and [Alon et al. \(2020\)](#) mainly focus on demographic differences among workers who can and cannot work remotely.

1 Measuring Exposures of Production to Covid

We begin with a brief description of our construction of exposure measures from the data.

1.1 Workers’ ability to work remotely

Following the rapid increase in cases throughout the US, many employers as well as state and local governments quickly imposed restrictions requiring that workers stay at home, leading to what is essentially the largest global experiment in telecommuting in human history. Our starting point is the simple premise that supply-side disruptions are likely to be more severe in occupations/industries for which workers have had little to no ability to or experience with telework in the past. Accordingly, our measure of industry exposure to work disruptions due to Covid-19 builds on [Alon et al. \(2020\)](#), who use data from the Leave and Job Flexibilities module of the American Time Use Survey (ATUS) in 2017 and 2018 ($n = 10,040$), which asks several questions about workers’ ability and past experiences with working from home. Our preferred measure utilizes responses to two different questions, though the module also includes several additional questions about reasons for and frequency of remote work. We obtain the ATUS microdata from IPUMS.²

Crucially, the survey draws a distinction whether workers are *able* to tele-commute, as opposed to actually regularly tele-commuting, as the former is the relevant metric during a pandemic.³ The output of this procedure is an occupation/industry-level metric of the fraction of workers in each occupation that can in principle work from home. The first major question asks for a yes/no reply to the prompt: “As part of your (main) job, can you work at home?”. Using the Census’ person weights, approximately 78% of households answer yes to

²Sandra L. Hofferth, Sarah M. Flood, Matthew Sobek and Daniel Backman. American Time Use Survey Data Extract Builder: Version 2.8 [dataset]. College Park, MD: University of Maryland and Minneapolis, MN: IPUMS, 2020. <https://doi.org/10.18128/D060.V2.8>

³For example, the Census’ American Community Survey asks whether workers worked from home last week, which captures regular telecommuting behavior. According to the Census Bureau, around 4.3% of workers worked from home according to this measure in 2010 ([Mateyka, Rapino, and Landivar, 2012](#)).

this question. Alon et al. (2020) construct a measure of telework experience by identifying the share of workers in a given occupation that, according to their answers to this question, are able to telecommute, and provide several facts about the share of workers in various demographic groups which are employed in occupations which can be performed from home.

Our preferred measure also makes use of responses to one additional question, “Are there days when you work only at home?”, which is only asked to those who say that they are able to work from home. Around 51% of households who are able to work from home also indicate that they have worked days entirely from home. In our view, answering this question in the affirmative provides a sharper classification of workers who will be more likely to be able to perform the majority of their job responsibilities from home, as opposed to, say, being able to perform a subset of tasks (e.g., answering emails/phone calls) remotely. For example, 64% of computer and information systems managers (occupation 110) say that they can work from home, and 47% of them have worked days only from home. These same proportions are 59% and only 13% for medical and health services managers (occupation 350), a group which, in our view, is a part of a population which is more likely to be unable to work full-time from home as effectively.⁴

In brief, we classify a surveyed worker as ‘able to work from home’ if they answer ‘yes’ to both questions above. We then compute measures of industry and occupation exposure by aggregating these survey responses across employees according to the industry and occupation codes which appear in the ATUS. In brief, our measure of industry exposure is

$$\text{Covid-19 Work Exposure}_I = 1 - \% \text{ of workers able to work from home}_I, \quad (1)$$

which is computed as a weighted average of individual-level responses aggregated so as to be nationally representative using the BLS’ person weights. If fewer than 5 survey respondents are directly employed in a given Census industry, we instead extrapolate using a weighted average of occupation-based measures.⁵ Given that an individual’s occupation likely provides

⁴As further evidence of a sharper distinction, among households who provide non-missing replies to the question “What is the main reason why you work at home?”, 60% of households who have worked days only from home are about twice as likely to list “job requires working at home”, “reduce commuting time or expense”, or “personal preference”, which is significantly higher than the 31% frequency for other workers (t statistic on difference = 12.1). By way of contrast, in the group of workers who say that they have worked from home but have never worked days only from home, the most common answer to this question is “finish or catch up on work”, which is selected 36% of the time, a significantly higher than the 14% of the time for those who have worked days from home ($t=7.3$).

⁵Specifically, we use data from the (considerably larger) 2016 American Community Survey to estimate the share of employees for each occupation by industry. We choose 2016 so that the occupation and industry codes coincide with those used in ATUS. American Community data are also taken from IPUMS: Steven Ruggles, Sarah Flood, Ronald Goeken, Josiah Grover, Erin Meyer, Jose Pacas and Matthew Sobek. IPUMS USA: Version 10.0 [dataset]. Minneapolis, MN: IPUMS, 2020. <https://doi.org/10.18128/D010.V10.0>

a more accurate description of the types of tasks that a worker performs on a daily basis, we elect to use the occupation-based measure in person-level regressions below—though similar results obtain if we use the industry-based measure. In general, we also find similar results if we use the more inclusive Alon et al. (2020) measure instead.

As most of our outcomes by industry use NAICS-based classifications, we crosswalk between the ATUS industry codes and NAICS industries.⁶ We aggregate most outcomes, when available, to the 4-digit NAICS level given that the industry codes available in the IPUMS ATUS extract roughly correspond with this level of aggregation.

Most industries are highly exposed, the mean value of the measure is approximately 0.7. Yet, there is considerable dispersion across NAICS industries—the cross-sectional standard deviation of our measure across 4-digit NAICS industries is approximately 0.20. Clearly, some industries are more exposed than others. For example, General Merchandise Stores (NAICS 4523) and Meat Production (NAICS 3116) have an exposure measure of close to 1, since almost none of the workers in that industry report that they can work from home. By contrast, software publishers (NAICS 5112) is an industry in which the vast majority of workers report they can work from home, and accordingly has an exposure of just 0.38.

In addition, we perform some manual adjustments to the ATUS work exposure measure. For certain industries, we set their work from home exposure to 1, giving them “full exposure.” These are largely industries that have been almost completely shut down and thus, even if some of their workers have the flexibility to be able to work from home in normal times, they cannot continue business as usual during lockdowns in a pandemic. These industries include: 4811 Scheduled Air Transportation, 5121 Motion Picture and Video Industries, 5151 Radio and Television Broadcasting, 5615 Travel Arrangement and Reservation Services, 7111 Performing Arts Companies, 7112 Spectator Sports, 7113 Promoters of Performing Arts, Sports, and Similar Events, 7114 Agents and Managers for Artists, Athletes, Entertainers, and Other Public Figures, 7131 Amusement Parks and Arcades.

1.2 Critical Industries

The Covid-19 crisis has required limiting interactions between individuals and thus a need to classify industries as essential or non-essential. The Cybersecurity and Infrastructure Security Agency (CISA) provided guidelines to states about what kinds businesses should remain open. Keeping track of essential industries can enhance our analysis of work from home exposure

⁶We make use of the crosswalks created by Evan Soltas, available here, which we update to use the 2017 NAICS code system: <https://dataverse.harvard.edu/dataset.xhtml?persistentId=doi:10.7910/DVN/07JLIC>

because if a business is allowed to stay open, then it may be irrelevant if their workers can telecommute. We start with Pennsylvania’s guidelines largely because they provide a list, based on the CISA guidance, of essential industries at the 4 digit NAICS (2017) level.⁷ These industries primarily correspond to the production and sale of food and beverages; utilities; pharmacies; transportation; waste collection and disposal; and some healthcare and financial services.

While the essential industry classification is a good place to start, we alter it for two basic reasons. First the classification of essential industries seems coarse in certain cases. For instance, the NAICS code 4831 is “Deep Sea, Coastal, and Great Lakes Water Transportation” and is listed as essential by Pennsylvania. While some of the firms in this industry are shipping companies, the largest firms in this industry are cruise ships, which clearly have not been permitted to maintain business as usual. Second, the CISA list was somewhat inclusive in what types of industries were classified as providing critical infrastructure. We therefore removed from the critical list industries that faced severe restrictions to operating at a scale close to or even higher than pre-pandemic baselines. For example, restaurants, restaurant suppliers, and airlines have been permitted to remain open, however their patronage has decline dramatically due to quarantines and heavy restrictions on domestic and international passenger travel. Given that we exclude the list of critical industries from the bulk of our empirical analysis, our choices of narrowing down the critical industry list can be viewed as conservative. Appendix Table A.1 provides the list of critical industries.

We validate our critical/non-critical industry classification using weekly foot traffic data from SafeGraph.⁸ SafeGraph collects anonymized information on location activity from a large panel of mobile devices. For more than 5 million points of interest (POIs), we can observe aggregated daily activity of users in the panel. As activity exhibits strong within-week seasonal patterns, we aggregate the data to the weekly level.⁹ The median POI receives 18 visits per week, and the distribution of activity is highly right skewed, with the 90th, 95th and 99th percentiles having 110, 186, and 623 hits respectively.

If our classification is accurate, we would expect to see a significantly smaller decline

⁷The CISA guidance is available at <https://www.cisa.gov/publication/guidance-essential-critical-infrastructure-workforce>, and the full Pennsylvania list is available here: <https://www.scribd.com/document/452553026/UPDATED-5-45pm-March-21-2020-Industry-Operation-Guidance>

⁸We are grateful to SafeGraph for making the data freely available to our research team and the broader community for Covid-19 related work. Further information about the data are available here: <https://docs.safegraph.com/docs/weekly-patterns>.

⁹Consistent with the recommendations of SafeGraph researchers, we scale total weekly activity by a moving average the total number of devices in the panel over the prior week for each point of interest prior to aggregating.

in foot traffic in critical than non-critical industries—starting from the middle of March 2020 when Covid-19 awareness and state-mandated lockdowns went into effect. To test this hypothesis, we then aggregate foot traffic across all POIs to the 4-digit NAICS level so as to match our critical industry classification. For each 4-digit industry, we compare activity in week t with a baseline level of average activity: the mean of weekly activity over the period beginning with the week of January 6-12 and ending with the week of February 10-16. Specifically, we estimate

$$\log \left(\frac{\text{Total Foot Traffic in week } t \text{ in Industry } I}{\text{Pre-period Average Foot Traffic of Industry } I} \right) = a_t + \beta_t \text{Critical Industry}_I + \varepsilon_{I,t}. \quad (2)$$

When estimating (2), we weigh observations by total industry employment, and, to minimize the effect of outliers, we winsorize these industry indices at the 1st and 99th percentiles.¹⁰

Figure 2 plots the results. Panel A reports average levels of our activity indices for critical and non-critical indices, respectively, along with 95% confidence intervals. Both sets of industries followed essentially identical trends in January and early February, then experienced a significant decline in foot traffic which dramatically accelerated in the middle of March of 2020. Though the Covid-19 pandemic affected almost all establishments, we can see that the decline is smaller for industries classified as critical. Panel B compares differences in traffic between the two industries by plotting the estimated coefficient β_t in equation (2) above. It shows that this decline was significantly smaller for industries that we identified as providing critical infrastructure. We interpret these results as supporting our industry classification into ‘critical’ and ‘non-critical’ industries.

1.3 Descriptive Facts

Figure 1 plots the distribution of the measure across NAICS4 industries. We report results separately for critical and non-critical industries. We note that most industries have relatively high values of Covid-19 work exposure; the average is equal to approximately 0.75 for critical and 0.7 for non-critical industries. More importantly, however, we see there is considerable dispersion in our measure—the cross-sectional standard deviation is approximately 0.20. The bulk of our paper explores the extent to which these cross-sectional differences are predictive of differential economic outcomes during the pandemic.

Table 1 illustrates how our industry Covid-19 work exposure measure is related to firm characteristics; due to data availability, we restrict attention to publicly-listed firms. Panel A

¹⁰Total NAICS4 employment is taken from the Census’ 2017 Statistics of United States Businesses tables: <https://www.census.gov/data/tables/2017/econ/susb/2017-susb-annual.html>

shows results for all industries, while Panel B restricts to the non-critical industry sub-sample. Two patterns stand out. First, we see that firms in the high-exposure category tend to be both larger. For instance, focusing on the sub-sample of non-critical industries, the median firm in the top quartile of the Covid-19 work exposure measure has 4.3 thousand employees; by comparison, the median firms in the bottom quartile has 1.5 thousand employees. Second, there is some evidence that firms in the least exposed industries have more intangibles than firms in the most exposed industries: these firms have higher market valuations (median Tobin’s Q of 2.1 for the most exposed vs 1.3 for the least exposed); have lower ratios of physical capital (PPE) to book assets (0.17 vs 0.61); and spend significantly more on R&D and SG&A than firms in the most exposed industries.¹¹ This is consistent with the view that firms with more intangibles have more jobs that can be done remotely than firms that rely more on physical assets. Last, firms in the most exposed industries are more profitable in terms of bottom-line accounting measures (return-on-assets) but this difference is driven by higher spending on intangibles and/or fixed costs by firms in the least exposed industries.

2 Covid-19 Work Exposure and Economic Performance

So far, we have constructed a measure of exposure to Covid-19 work disruptions using data from the 2017 and 2018 ATUS. Here, we explore the extent to which this Covid-19 work exposure measure is able to predict differences in economic performance across industries and individual workers. Our outcome variables include data on employment outcomes at the industry and worker level, as well as forward-looking variables that are indicative of future economic performance—stock returns; analyst forecasts; and default probabilities.

Each of these variables have distinct advantages and disadvantages. Data from financial markets and financial analysts are forward-looking, but are only available for public firms—which may be less exposed to supply-side disruptions than smaller private firms. Employment data are more representative of the universe of firms, but are available with a lag and may not accurately reflect outcomes for firm owners.

¹¹Corrado, Hulten, and Sichel (2009) and Eisfeldt and Papanikolaou (2013) argue that higher SG&A expenditures are associated with higher investment in intangibles. That said, Eisfeldt and Papanikolaou (2013) focus on within-industry differences, whereas these results reflect between-industry patterns. As such, these differences in SG&A could also reflect differences in operating leverage (importance of fixed costs) or differences in accounting practices.

2.1 Employment

We begin by exploring the extent to which our measure of production disruption due to the pandemic can predict differences in employment declines across industries. We use two sources for data on employment.

First, we focus on aggregated employment data from the Bureau of Labor Statistics (BLS). Each month, the BLS aggregates data from large surveys of firms’ establishments in order to construct estimates of total employment by industry. We make use of data from Table B-1a of the April employment report, which provides estimates of seasonally-adjusted employment at the 3-digit NAICS level for the vast majority of non-agricultural industries in the US economy.¹² While BLS reports monthly data for more detailed NAICS industries, measures for April 2020 are suppressed for a large number of the more disaggregated categories. As such, we conduct our analysis at the 3-digit level. For purposes of this analysis, we define a NAICS3 industry as critical if more than 50% of its pre-pandemic employment is associated with our list of 4-digit NAICS critical industries.

We estimate the following specification

$$\text{Employment Growth}_I = a + \beta \text{Covid-19 Work Exposure}_I + \varepsilon_I. \quad (3)$$

Here, the unit of observation is a 3-digit NAICS industry and the outcome variable is employment growth. We examine both monthly but also annual changes—that is, between April 2020 and either March 2020 or April 2019. Since the size of these industries varies greatly, depending on the specification, we weigh also weigh industries using total employment as of March 2020. Last, we report results either using the full sample, or by excluding the list of critical industries in Table A.1.

Table 2 and Figure 3 presents our results. Examining the Columns (1) through (8) of the table, we see an economically and statistically significant correlation between our exposure measure and industry-wide declines in employment that is robust across different specifications. In particular, a one-standard deviation increase in our Covid-19 work exposure measure is associated with a 6.8 to 21.4 percent greater decline in employment. The magnitudes are comparable when we focus on monthly or annual growth rates and are larger when we exclude critical industries and weigh industries by their total employment. These magnitudes are quite significant and comparable to wither the average decline in employment during this period (18 percent) or the cross-sectional standard deviation (16 percent).

The recent availability of CPS data allows us to explore outcomes at the level of individual

¹²Data were accessed here: <https://www.bls.gov/web/empst/ceseeb1a.htm>

workers. The advantage of doing so is twofold. First, by observing the characteristics of individual workers we can control for some variables that may be correlated with our Covid-19 work exposure. For instance, workers that can work remotely tend to be in white collar occupations (see e.g., [Dingel and Neiman, 2020](#)). By including controls for workers’ level of education, or past earnings, we can ensure that we are comparing otherwise similar workers. Further, analyzing outcomes for individual workers, and how these outcomes vary with observables, reveals a fuller picture of the effects of the Covid-19 on the supply side.

We use the April version of the Current Population Survey (CPS) which contains employment information for individual workers.¹³ We restrict the sample to adults of working age (25 to 60 years); that are present in the March 2020 survey; and report that they are ‘at work last week’ as of March 2020. Our sample contains 23,984 workers. In April of 2020, 19,664 out of these workers report they are at work; 2,144 report they are out of a job; while 1,257 report they have a job but were not at work last week. We include the first and last groups in our definition of employment for our regressions below.

We impose one other substantial restriction of the sample. As of the start of the year, the BLS changed its coding of occupations relative to prior years, and a crosswalk between the older vintage of occupation codes from ATUS and the newer codes in the 2020 CPS has not yet been developed. In part due to this technical reason and also given that several researchers have already documented a disproportionate increase in unemployment for lower income workers, we restrict attention to the subsample of workers who appear in the March/April 2020 core CPS and March 2019 Annual Social and Economic (ASEC) CPS surveys. This enables us to construct controls for an individual’s prior income and, motivated by evidence on potentially concentrated adverse effects for small businesses, firm size. For each worker, we assign an exposure measure based on her March 2019 occupation which is equal to one minus the fraction of ATUS respondents (weighted using the ATUS sampling weights) who had worked a full day from home.¹⁴

We estimate the following specification

$$\text{NotEmployed}_i = a + \beta \text{Covid-19 Work Exposure}_i + c Z_i + \varepsilon_i. \quad (4)$$

¹³There are some possible selection issues. IPUMS notes that: “Interviews for April were conducted exclusively by phone. The two Census Bureau call centers that usually assist with the collection of CPS data remained closed. Response rates continued to be low in April, over 10 percentage points below the average (see below). Response rates continued to be particularly low among rotation groups one and five who would have normally received a visit from the enumerator. Month-in-sample one and five response rates were similar to those same groups in March. Additionally, those households that entered the survey for the first time in March had a similarly low response rate for their second interview in April.”

¹⁴Note that we also assigned an alternative measure based on each worker’s March 2020 industry and obtain similar results.

Our main outcome variable is a dummy variable that takes the value of 1 if the worker was not ‘at work last week’ in the April 2020 CPS survey—which therefore includes both unemployed and furloughed workers.

Since the CPS contains information on workers’ occupation, we use the occupation-level measure of our Covid Work exposure rather than the industry aggregate—though, using industry aggregates produces largely comparable results. Depending on the specification, the vector of worker-level controls and interaction terms Z_i includes gender dummies; college education; whether the worker has children younger than 14 years old; education (a college graduate dummy); worker age; worker earnings as of 2019 (quartile dummies); and firm size dummies. We cluster the standard errors by occupation and industry (using Census codes). Table 3 shows results.

Examining Table 3, several facts stand out. First, as we see in the first three rows of the table, workers in occupations that are less able to work remotely (higher Covid-19 work exposure) are more likely to stop working. These effects are not absorbed by worker characteristics—as we see in columns (2) and (3)—suggesting that our Covid-19 work exposure measure is not simply capturing differences in the composition of the work force. Further, the point estimates are somewhat larger for non-critical industries relative to critical industries. Focusing on column (3)—which includes controls for worker gender, age, education, prior earnings, and firm size—a one-standard deviation increase in our covid-19 work exposure measure is associated with a 4.5 percentage point increase in the probability of a worker in a non-critical industry being without employment in April 2020, compared to a 1.3 percentage point increase for a worker in a critical industry, that is however statistically not significantly different from zero. Hence, in the remainder of the paper, we restrict attention to non-critical industries.

One potential concern with these results is that they could simply reflect differential employment trends in white-collar versus blue-collar occupations. Column (4) of Table 3 performs a placebo exercise, in which we repeat the analysis for the February CPS sample—well before the effects of the pandemic became apparent. Examining the results we note that none of the coefficients of interest are statistically different from zero.

We next allow the coefficient β on the Covid-19 work exposure measure in equation (4) to vary with worker characteristics Z_i . In all specifications with interactions, we always include dummies for all levels of the categorical variable of interest as controls. Doing so reveals how the employment status of different workers varies in response to the same level of work disruption due to Covid-19.¹⁵

¹⁵In additional specifications, we verify that many of these patterns persist even if we include occupation

Figure 4 summarizes our findings. In Panel A of the figure, we see an economically and statistically significant difference in how the employment status of workers of different income levels is related to our Covid-19 exposure measure. A one-standard deviation increase in our work exposure measure is associated with a 9.2 percentage point increase in the likelihood of non-employment for workers at the bottom quartile of the earnings distribution—compared to just a 1.6 percentage point increase for workers in the top quartile. The fact that we see such a differential response of employment status to the feasibility of remote work for employees with different earnings levels has several interpretations. One possibility is that firms try to retain their most able—and highest paid—employees and reduce employment for workers of lower skill levels first.

Another possibility is that these responses reflect differences in age or the gender pay gap. Panel B of the Figure shows that there is some evidence that the employment status of younger workers responds more by approximately a factor of two than older workers to Covid-19 work disruptions, but the coefficients are imprecisely estimated so the difference is not statistically different from zero. Panel C shows that these differences do not merely reflect the gender pay gap. More importantly though, Panel C reveals that the employment status of female workers is more sensitive to work disruptions than the status of male workers, for all income levels. Panel D shows that the workers most adversely affected by the work disruptions due to Covid-19 are female workers with young children and without a college degree. For this group, a one standard deviation increase in our Covid-19 work exposure measure is associated with about a 15 percentage point increase in non-employment—which is three times higher than the average response among all workers.

In sum, we find that our Covid-19 work exposure measure is an economically significant predictor of employment. Workers in occupations that cannot work remotely are significantly more likely to have lost their employment status in April 2020. This correlation is evident both in cross-industry comparisons but also in individual worker regressions

2.2 Revisions in Revenue Forecasts

We next examine the ability of our measure to predict revisions in analyst forecasts regarding the economic performance of these industries. Specifically, we use consensus forecasts of firms’ revenues over various horizons from Capital IQ as of various points in time. We begin by comparing the change revenue forecasts for the same accounting period (e.g., 2020Q2) across two points in time, February 14 and May 15, 2020. Later, we illustrate how these forecasts

and/or industry fixed effects, implying that we can detect similar differences even within occupations/industries. These results are suppressed for brevity and are available upon request.

evolved on a weekly basis. We focus on forecasts horizons up to three years ahead, that is, Q2 through Q4 of 2020, and full year forecasts for 2020–22. We use the Capital IQ ‘consensus forecast’; to minimize measurement error, we require that each firm has at least 3 individual forecasts. For each firm f in the sample, we compute the percent change in revenue forecast from February to May 2020,

$$\frac{\text{Revenue forecast for Period } \tau, \text{ as of May } 2020_f}{\text{Revenue forecast for Period } \tau, \text{ as of February } 2020_f} - 1. \quad (5)$$

We then aggregate the non-missing firm-level revenue forecasts to the 4-digit NAICS level, weighted by the corresponding level of the firms’ February 2020 forecasts for the same period,

$$\text{Forecast Revision}_I^\tau = \frac{\sum_{f \in I} \text{Revenue forecast for Period } \tau, \text{ as of May } 2020_f}{\sum_{f \in I} \text{Revenue forecast for Period } \tau, \text{ as of February } 2020_f} - 1. \quad (6)$$

We re-estimate equation (9), but we now replace the dependent variable with the revision in analyst forecasts in (6)

$$\text{Forecast Revision}_I^\tau = a_\tau + \beta_\tau \text{Covid-19 Work Exposure}_i + \varepsilon_i^\tau. \quad (7)$$

Our dependent variable is the revision in analysts’ revenue forecasts for period τ between February and May 2020, aggregated to industry i . To conserve space, we focus our preferred specification in which we restrict the sample to non-critical industries and weigh observations by the number of employees in each industry; using equal weights or weighting by the number of firms leads to quantitatively similar results. Standard errors are robust to heteroskedasticity (White, 1980).

Columns (2) to (7) of Table 4 presents our findings. Column (2) shows the effect of the exposure measure on revenue forecasts revisions for Q2 2020. A one-standard deviation increase in the exposure measure is associated with a 7.4 percent decline in analysts’ revenue forecasts. Importantly, the effect is quite persistent, though the magnitudes do decline with the forecast horizon τ , as we can see from comparing the magnitudes across columns. Figure 7 plots the estimated coefficients as a function of the forecast horizon τ . We see that financial analysts expect that the direct economic cost of the pandemic to subside significantly over the course of 2020: a one-standard deviation increase in the exposure measure is associated with a 2.7 percent decline in revenue for Q3, while the estimate for Q4 2020 is equal to 1.2 percent. The overall estimate for 2020 is equal to 2.4 percent. Extending our analysis to 2021 and 2022, we note that our estimates are significantly weaker at 1.8 and 1.3 percent,

respectively—though still statistically significant—suggesting that analysts forecast that costs of these supply side disruptions are expected to persist for several years.

2.3 Default Probabilities

So far, we have seen that our Covid-19 work exposure measure predicts declines in both employment declines as well as expected revenue across industries. We next examine another forward-looking measure, expected probabilities of default.

We obtain estimates of default probabilities from the Risk Management Institute (RMI) of the National University of Singapore. RMI generates forward-looking default probabilities for issuers on a daily basis for maturities of 1, 3, 6, 12, and 24 months ahead using the reduced form forward intensity model of [Duan, Sun, and Wang \(2012\)](#). These measures have been shown to work well in forecasting applications and are available for a very wide array of firms (over 70,000 publicly listed firms worldwide).¹⁶ We next compute the first difference of the default probability over our the May–Feb 2020 period and aggregate these default probabilities at the industry level (4-digit NAICS) by averaging across firms (weighted by employment).

We estimate the following specification,

$$\text{Default Probability}_I^\tau = a_\tau + \beta_\tau \text{Covid-19 Work Exposure}_I + \varepsilon_i^\tau. \quad (8)$$

The outcome variable is the industry-level probability of default over the next τ months. As before, we restrict the sample to non-critical industries and weigh observations by the number of employees in each industry.

Table 5 and Figure 8 present the results. Examining Table 5, we see that differences in our Covid-19 work exposure measure are associated with increased probabilities of default. This correlation is both statistically and economically significant and is monotonically increasing in the forecast horizon τ . For instance, a one-standard deviation increase in our measure is associated with a 0.26 percentage point increase in the probability of default over the next 6 months and a 0.48 percentage point increase over the next 2 years. Given that the average probability of default over these horizons is 0.26 percent and 1.24 percent, respectively, these magnitudes are quite substantial.

¹⁶For example, [Gallagher, Schmidt, Timmermann, and Wermers \(2020\)](#) use these probability estimates to study changes in portfolio risk of international portfolios of securities owned by US money market funds, and illustrate that the default probabilities closely track CDS spreads. For additional details on the database, see <https://rmicri.org/en/>.

2.4 Stock Market Performance

So far, we have seen that differences in our Covid-19 work exposure measure are correlated with differences in analyst forecasts of revenue growth and default probabilities. Though forward looking, both of these measures are somewhat subjective and may not necessarily reflect the ‘average’ beliefs in the economy. Our next outcome variable partly addresses this concern, as it focuses on differences in stock market valuations across industries.

We use data on stock returns is from the *Compustat* Daily updates; specifically, we use the *Total Return* variable which corresponds to holding period returns. We restrict attention to common stocks of firms that have headquarters in the United States; are traded on NYSE, AMEX, or NASDAQ; and eliminate financial and real estate firms (NAICS codes 52 and 53).¹⁷ Almost all of the industries performed negatively during this period—the cross-sectional average decline is equal to approximately 26 percent. Yet, there is considerable cross-industry dispersion—the cross-sectional standard deviation is approximately equal to 18 percent. A select few industries experienced price appreciation: firms in the grocery store industry (NAICS 4451) saw a 21 percent increase in stock market values; firms in electronic shopping (NAICS 4541) appreciated by approximately 13 percent. Others such as airlines (NAICS 4811) experienced stock market declines of more than 65 percent.

Figure 5 illustrates our main results graphically via a scatter plot of our exposure measure versus the stock market performance of these industries. Essential industries are marked in red, while the trend line is estimated in the sample of non-essential industries. We note some significant outliers that do not fit the line. For example, NAICS code 5414 corresponds to interior designers; these workers can work remotely, but cannot act on their designs.

We relate differences in our work exposure measure to differences in cumulative stock market performance using the following specification,

$$\text{Stock Returns}_i = a + \beta \text{Covid-19 Work Exposure}_i + \varepsilon_i \quad (9)$$

The dependent variable corresponds to cumulative stock returns from February 14th through May 15, 2020. As before, we restrict the sample to non-critical industries. To ensure that our results are not driven by small industries with high idiosyncratic volatility, we estimate (9) using weighted least squares—where we weigh observations by the total number of employees

¹⁷We also exclude firms in the education sectors (6111–6114), because the remote exposures of employees of the listed firms employed in these sectors are likely to be quite different from those employed in the non-profit/government enterprises which comprise the vast majority of employment in these sectors. Likewise, we exclude fast food restaurants (NAICS 722513) from the sample, as their exposures are likely to be quite different from other firms in the restaurant industry.

(across firms in our Compustat sample) in each industry. Weighting by the number of firms in each industry leads to quantitatively similar findings. Standard errors are robust to heteroskedasticity (White, 1980).

Column (1) of Table 4 present our estimates. Examining the table, we see that our industry exposure measure is economically and statistically significant in accounting for differences in the economic performance across industries. The magnitudes are considerable: a one-standard deviation increase in the lockdown measure is associated with a 6.7 percent decline in stock prices during this period. Given that the cross-sectional standard deviation in industries' stock market performance during this period is approximately 16.6 percent, our measure captures a significant share of the overall dispersion.

In sum, we find that a measure of disruption exposure constructed with pre-2019 data is a statistically significant predictor of cross-industry heterogeneity in returns during the Covid-19 pandemic. That said, however, these estimates are somewhat at odds with the impact on stock returns we discuss above. Specifically, as we compare Columns (1) through (8) of Table 4, we see that a one-standard deviation increase is associated with 6.7 percent decline in stock prices, whereas the expected decline in revenues over 2020 and beyond is much smaller and short-lived. In reconciling these differences, a few possibilities emerge. First, firms profits may be substantially more affected than revenues; second, the differential stock return performance could also driven by differential increases in systematic risk during this period. After all, the January to May period of 2020 is a period of increased uncertainty (see e.g., Baker, Bloom, Davis, and Terry, 2020).

3 Real-time estimates of the supply-side disruption

In our analysis so far, we have developed a measure of industry exposure to production disruptions due to Covid and shown that heterogeneity in risk exposures are associated with cross-industry differences in economic performance during the pandemic period. Our analysis was essentially cross-sectional in nature as we focused on cumulative outcomes during the entirety of the pandemic period. However, our measure can also be used to construct a real-time indicator of news associated with these production disruptions. To do so, we exploit the high-frequency information in data from the financial markets.

In particular, we re-estimate equation (9) for the subsample of non-critical industries, while allowing the slope coefficient to vary over time,

$$\text{Stock Returns}_{i,t} = a + \beta_t \text{Covid-19 Work Exposure}_i + \varepsilon_{i,t}. \quad (10)$$

The realized time-series of the slope estimates β_t have a portfolio return interpretation. That is, they are a noisy (to the extent that our firm-level exposures are mis-measured) estimate of the ‘Covid-19 return factor’, that is, the source of common variation in returns that is related to the production disruptions as a result of the pandemic. (see, e.g. [Fama and MacBeth, 1973](#); [Cochrane, 2009](#), for more details). Intuitively, this factor is a long-short portfolio of industries based on their disruption exposure: it loads positively on industries in which a lower fraction of workers report that they can telecommute, while loading negatively on industries in which a higher fraction of workers report that they can work remotely. Specifically, the return on the Covid-19 factor can be expressed as

$$\hat{\beta}_t = \sum_i w_i (R_{i,t} - \bar{R}_t^{emp}), \text{ where } \bar{R}_t^{emp} \equiv \frac{1}{N} \sum_{i=1}^N \frac{emp_{i,0}}{emp_0} R_{i,t} \equiv \sum_{i=1}^n e_i R_{i,t}, \quad (11)$$

where e_i is the employment share of industry i . The portfolio weight industry i receives in the Covid-19 portfolio can be written as

$$w_i = \frac{e_i \left[X_i - \sum_{l=1}^N e_l X_l \right]}{\sum_{j=1}^N e_j \left[X_j - \sum_{k=1}^N e_k X_k \right]^2} = \frac{e_i \left[X_i - \bar{X}^{emp} \right]}{\sum_{j=1}^N e_j \left[X_j - \bar{X}^{emp} \right]^2}, \quad (12)$$

where X_i is our (predetermined) measure of exposure for firm i , so the portfolio holds long positions in stocks with exposure above the employment-weighted average exposure and short positions otherwise.

Figure 10 summarizes how these portfolio weights vary across different broad sectors (2-digit NAICS codes). The portfolio overweighs industries whose workers can perform their tasks from home, and underweighs sectors where workers cannot work remotely. Consistent with the discussion so far, we see that firms in retail trade, and accommodation and food services receive large positive weights; by contrast firms in professional services and information technologies receive negative weights. Appendix Table A.2 contains the full list of weights on NAICS 4-digit industries.

Figure 9 plots these factor realizations in blue, along with returns on the market portfolio in red. First, we note that the correlation between our factor and the market portfolio in the three months before the pandemic period, the correlation is significantly negative (approximately -0.4), which suggests that the industries most exposed to the covid pandemic are industries with low systematic risk during normal times. However, given the dominance of covid-related news during this period, the correlation with the market during the pandemic period is positive, though modest (it ranges from 0.1 to 0.2 depending on how the factor is

constructed). Further, we see in Figure 9 that extreme daily realizations of our factor are associated with significant news about the pandemic.

In brief, we see that realizations of our ‘Covid-19 factor’ largely tracks the unfolding of news related to the pandemic. As of May 15 2020, this long-short portfolio had lost roughly 50 percent of its value since the beginning of the year—compared to 10 percent for the broad market index. This pattern supports the view that Covid-19 is primarily a reallocation shock as not all sectors were symmetrically affected—which also echoes the views in [Barrero et al. \(2020\)](#). These results speak to how investors could construct an investment strategy that could significantly hedge future covid-19 related uncertainty. They could do so by taking a short position in our Covid-19 factor, which would involve taking the opposite position to the one described in Appendix Table A.2 .

Last, we also examine the real-time response of our two other forward-looking variables—revisions in analyst forecasts and estimated default probabilities. Figures 11 and 12 summarize our findings. Similar to our stock return evidence above, we see an increased divergence in revenue forecasts and expected default probabilities across high- and low-Covid 19 work exposure industries by the end of March and beginning of April 2020. Comparing the two figures, we see that default probabilities appear to respond a bit earlier than analyst revenue forecasts, and they seem to recover somewhat from their peaks by the end of April. That said, these differences could simply be due to the fact that analyst forecasts are released with some delay.

4 Conclusion

We characterize the supply-side disruptions associated with Covid-19 exploiting differences in the ability of workers across industries to work remotely. Our results uncover economically sizeable differences in economic outcomes for both workers and firms depending on the ability to work remotely. Sectors in which a higher fraction of the workforce is not able to work remotely experienced significantly greater declines in employment; significantly more reductions in expected revenue growth; worse stock market performance; and higher expected likelihood of default. Lower-paid workers, especially female workers with young children, were significantly more affected by these disruptions.

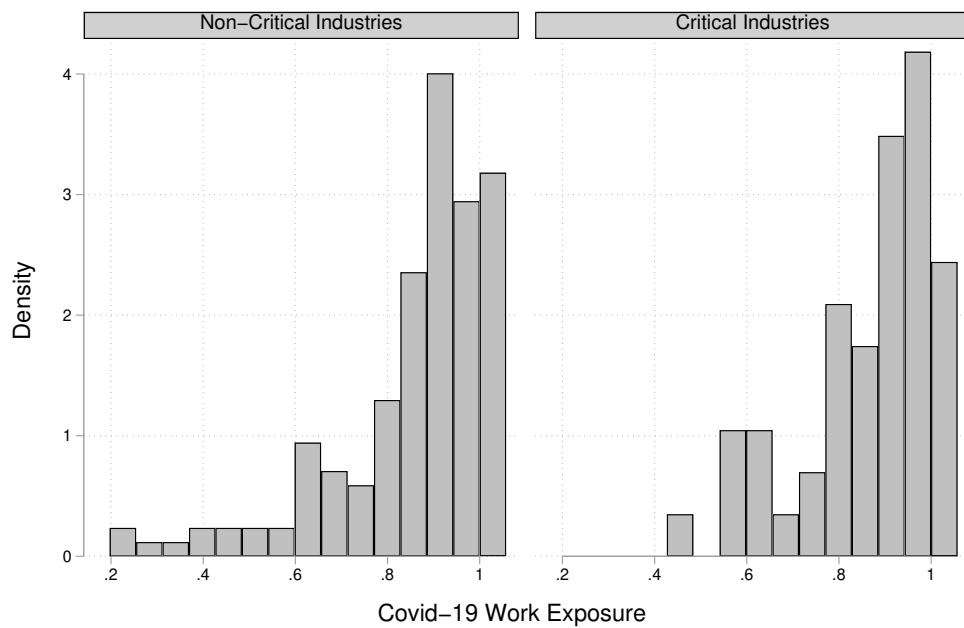
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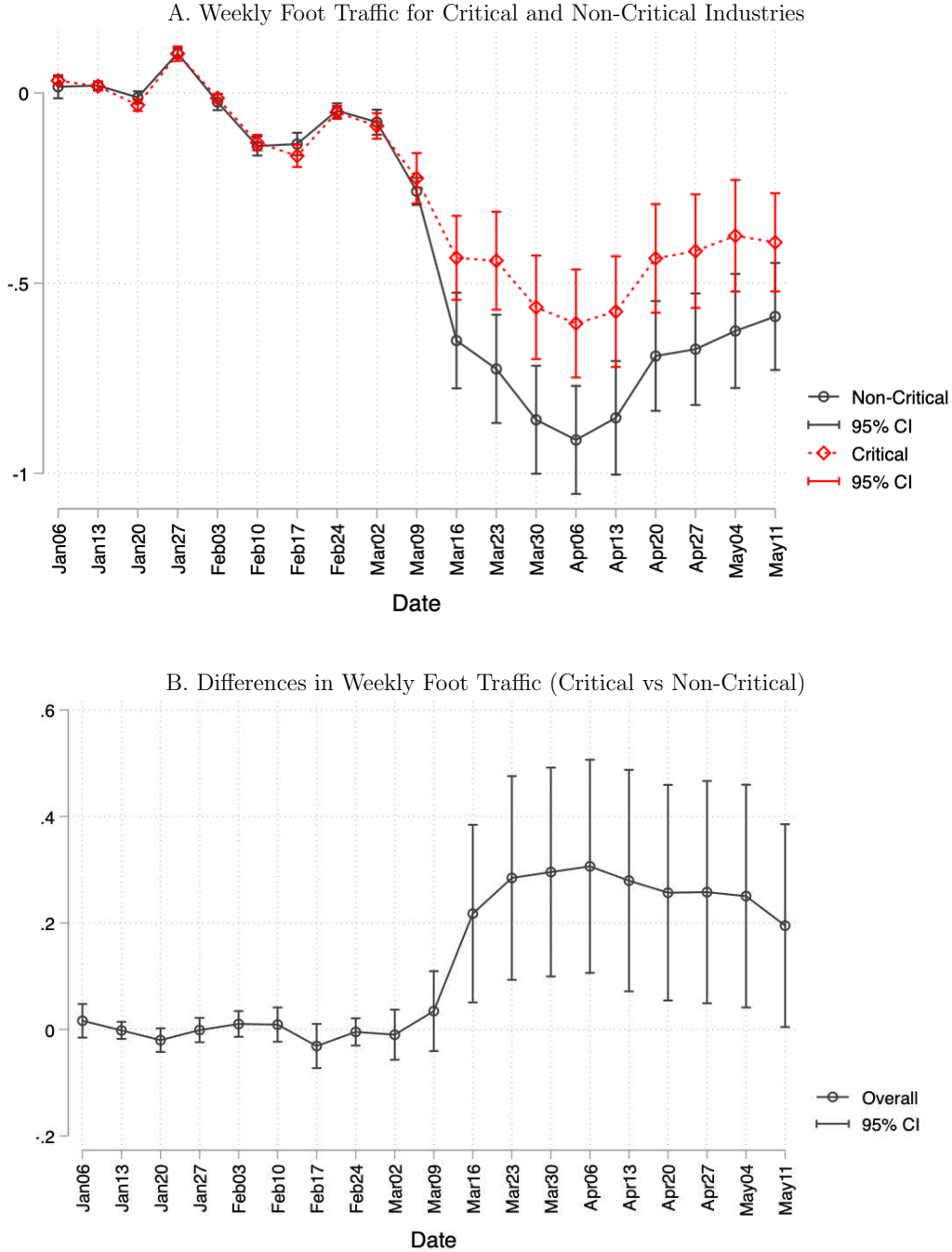
Figures and Tables

Figure 1: Distribution of Covid-19 Work Exposure Measure across Industries



The figure plots the distribution of the Covid-19 work exposure measure across critical (right panel) and non-critical (left panel) industries.

Figure 2: Changes in Foot Traffic across Critical and Non-Critical Industries



The figure documents the differential decline in average foot traffic between critical and non-critical industries—given our classification in Appendix Table A.1. Panel A plots the average change in weekly foot traffic— $\log(\text{Total Foot Traffic in week } t \text{ in Industry } I) - \log(\text{Pre-period Average Foot Traffic of Industry } I)$, along with 95 percent confidence intervals. Panel B plots the estimated $d\beta_t$ coefficients from equation (2) in the main document, which capture the differences in weekly foot traffic (relative to pre-period averages) for critical and non-critical industries. Pre-period averages are computed prior to February 14 of 2020.

Figure 3: Employment Growth and Covid-19 work exposure

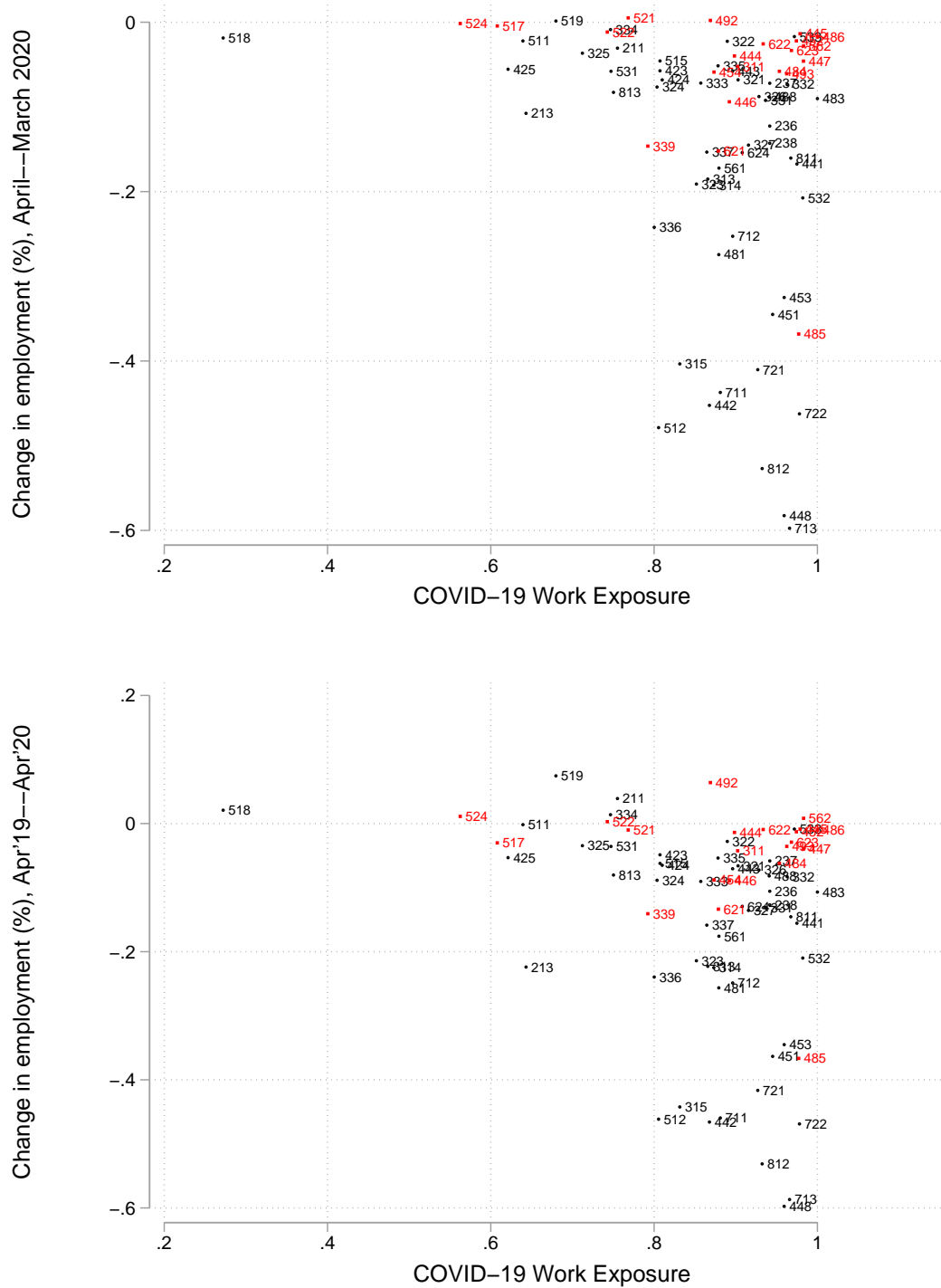
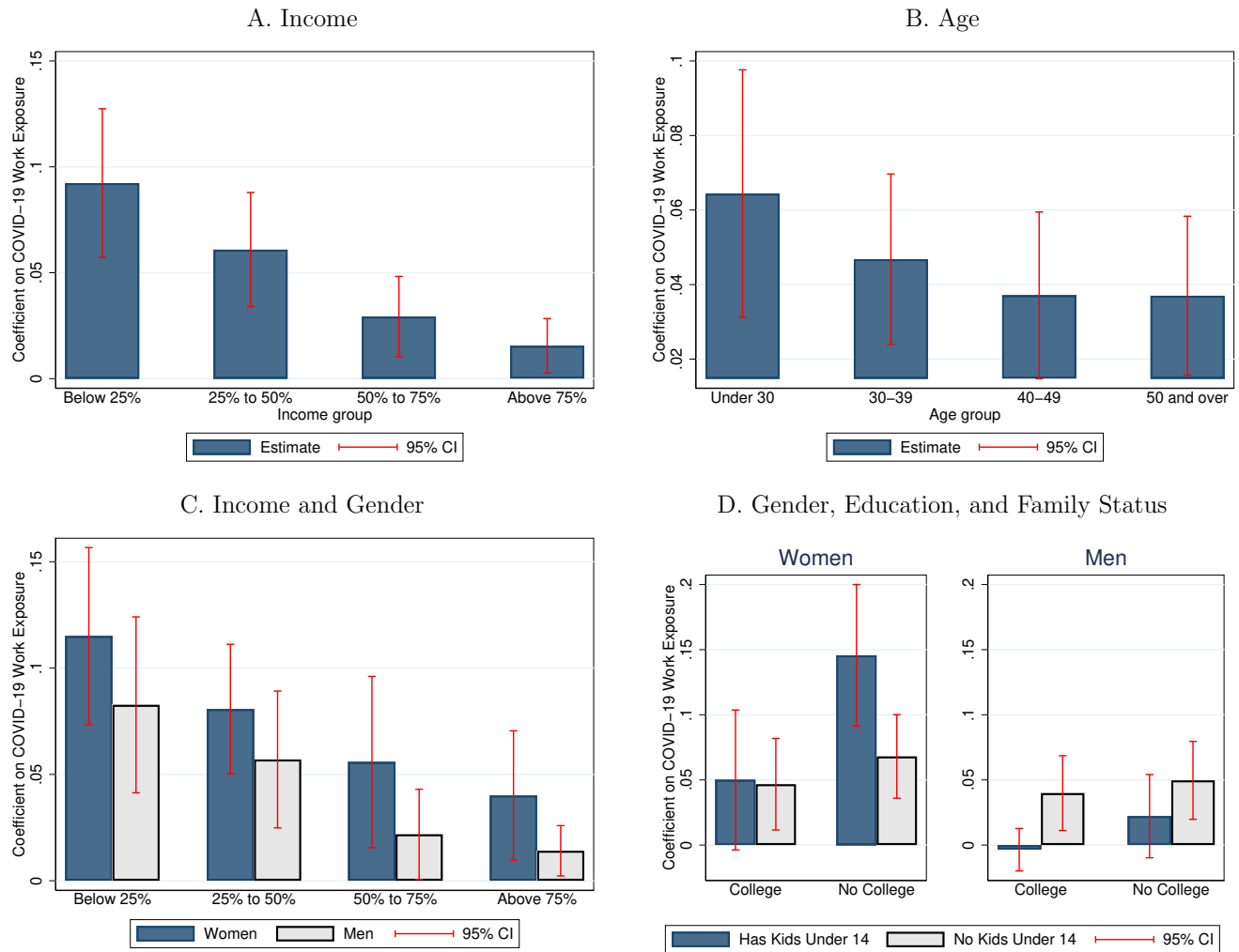


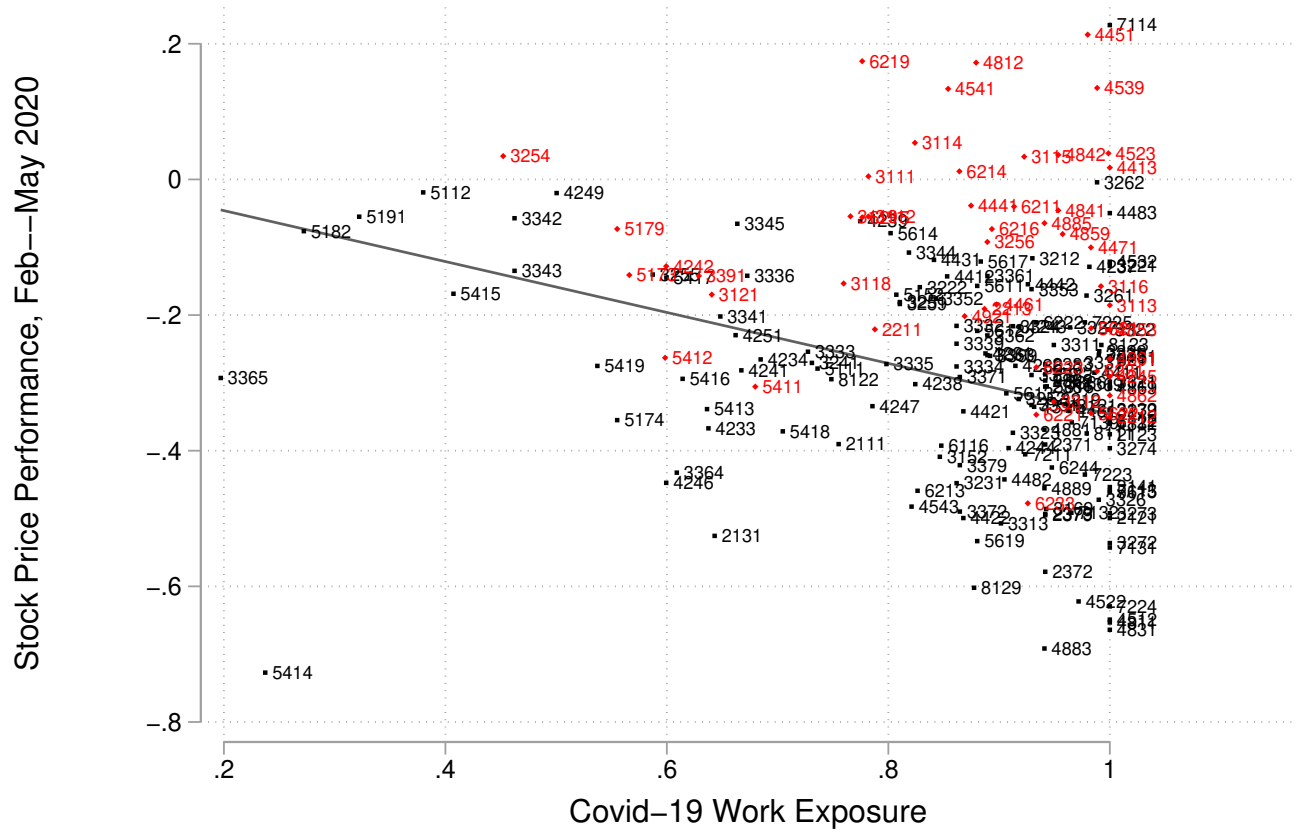
Figure plots the correlation between employment growth and Covid-19 work exposure at the 3-digit NAICS level. Top panel plots month-to-month changes (April vs March 2020) while the bottom plots year-on-year changes (April 2020 to April 2019). The points in red correspond to the critical industries listed in Appendix Table A.1.

Figure 4: Employment and Covid-19 work exposure: Worker Heterogeneity



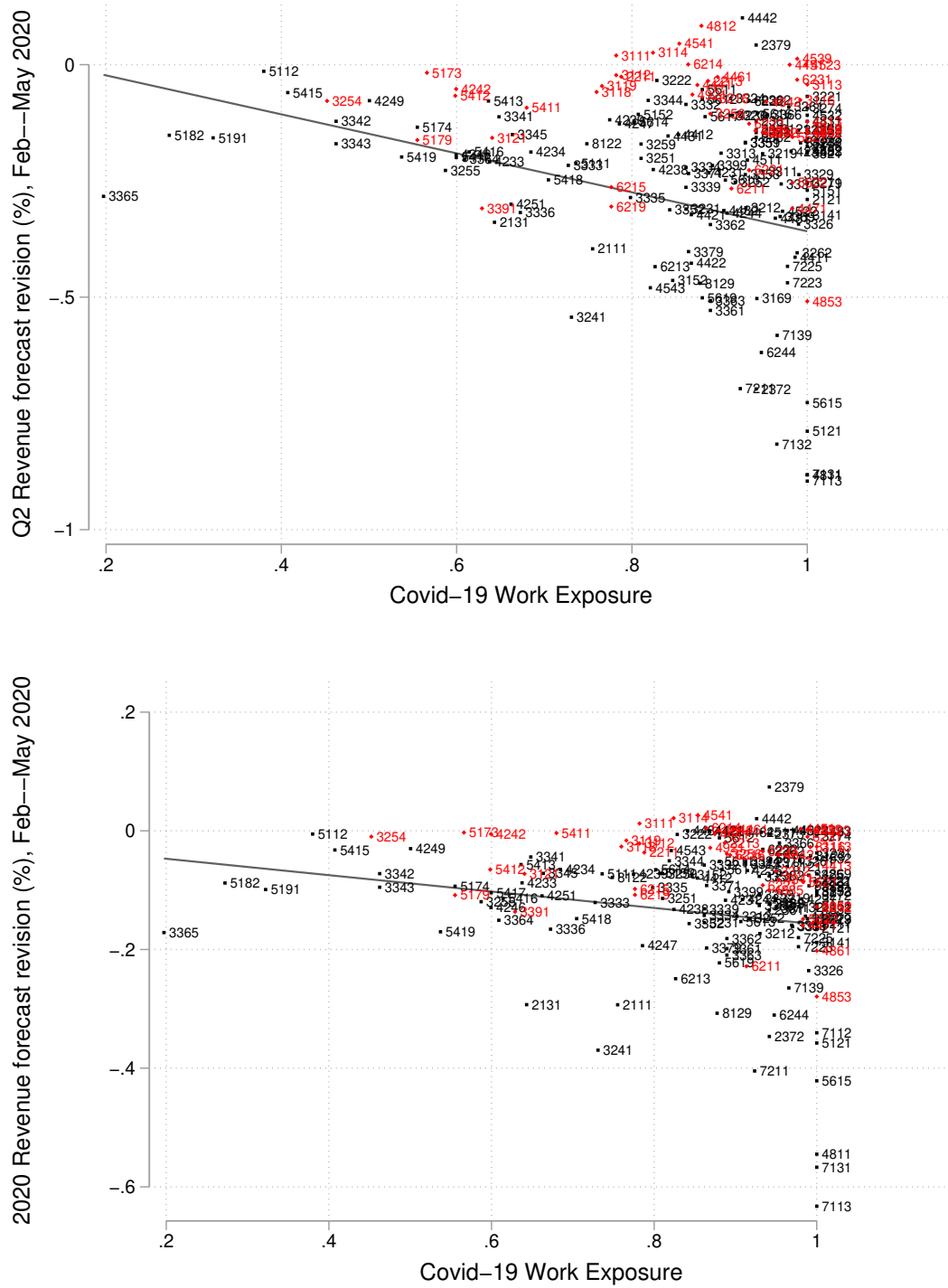
Figures plot how the coefficients of a regression of non-employment status on our Covid-19 work exposure measure vary with workers characteristics.

Figure 5: Stock Price change and Covid-19 work exposure



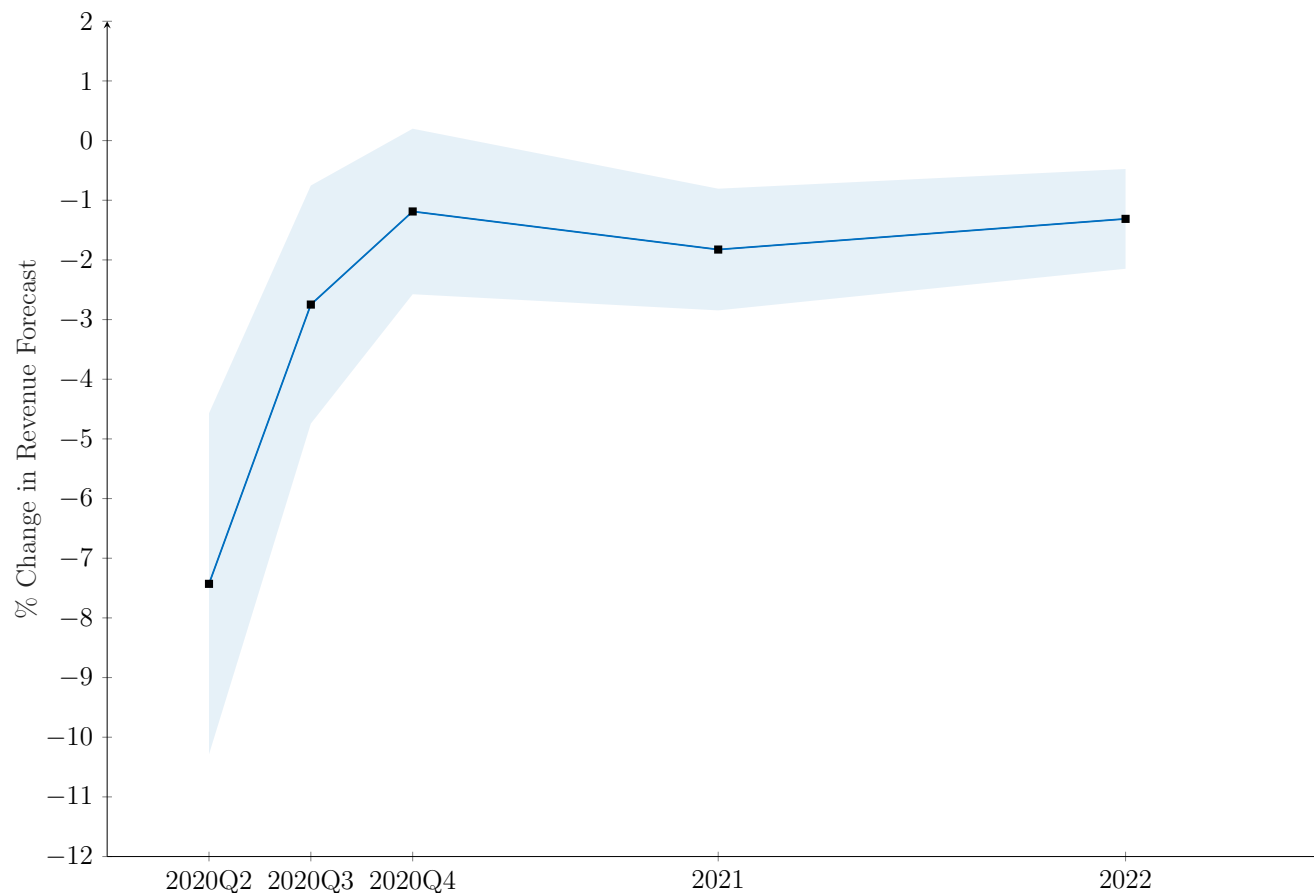
The figure plots the share price performance of different industries between mid-February to mid-May 2020 versus the Covid-19 work exposure measure. The points in red correspond to the critical industries listed in Appendix Table A.1.

Figure 6: Revenue forecast revisions and Covid-19 work exposure



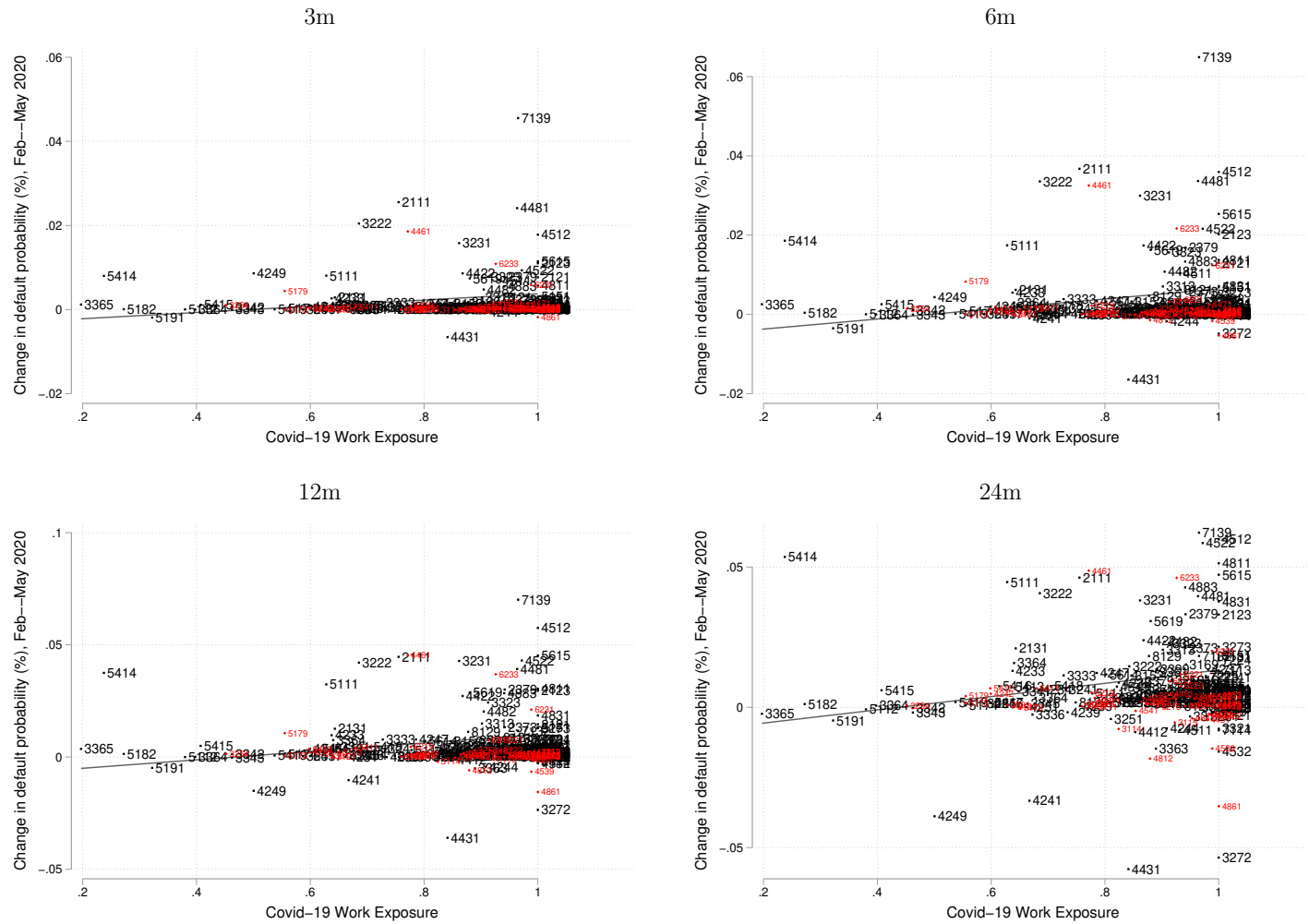
The top panel of this figure plots the revisions in revenue forecasts for Q2 2020 between mid-February and mid-May 2020 versus the Covid-19 work exposure measure. The bottom panel plots the corresponding revisions for the year 2020. The points in red correspond to the critical industries listed in Appendix Table [A.1](#).

Figure 7: Revenue forecast revisions relative to February 2020 forecast as a function of Covid-19 work exposure



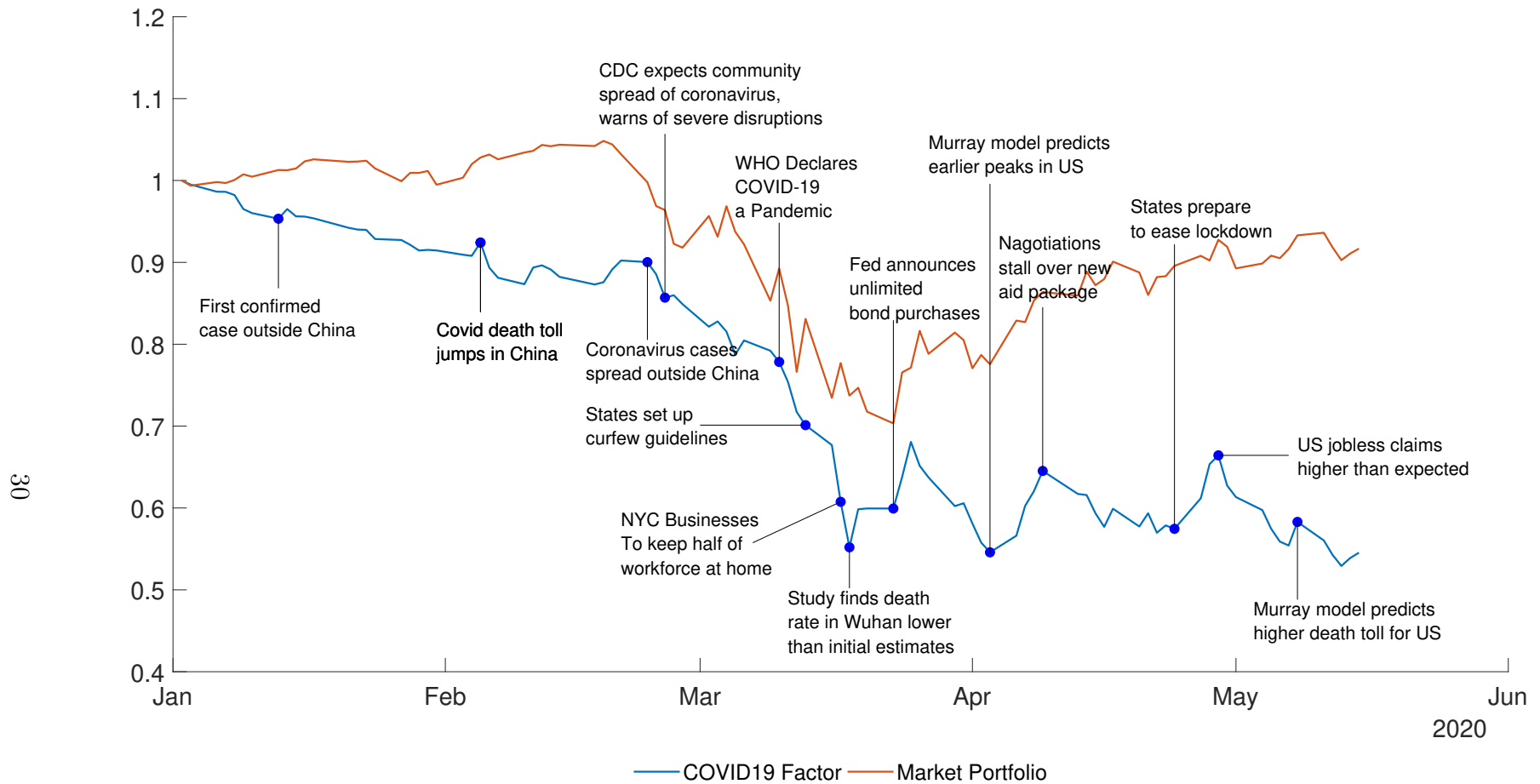
The Figure plots the estimated coefficients from equation (7) in the main document. Specifically, we plot the relation between revisions in industry-level revenue forecasts (from mid-February to mid-May 2020) as a function of their Covid-19 work exposure in the sub-sample of non-critical industries. The plotted coefficients correspond to columns (2)-(4) and (6)-(7) of Panel B of Table 4. Coefficients are standardized to a unit standard deviation change in the Covid-19 work exposure measure. Shaded areas correspond to 90% confidence intervals. Events are dated as if they occurred at the beginning of the trading day on the date of their announcement.

Figure 8: Default Probabilities and Covid-19 work exposure



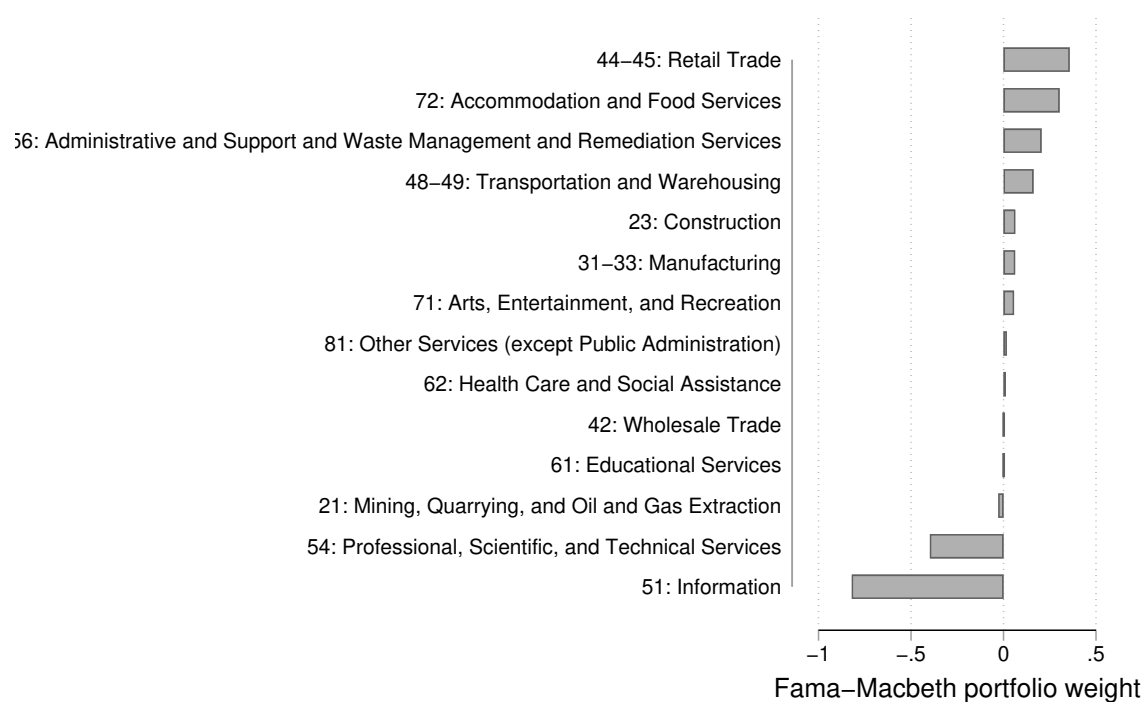
Panels of this figure plot changes in 3, 6, 12, and 24 month default probabilities for Q2 2020 between mid-February and mid-May 2020, respectively, versus the Covid-19 work exposure measure. The points in red correspond to the critical industries listed in Appendix Table A.1.

Figure 9: COVID-19 factor vs market



The figure shows the time-series of the estimated slope coefficients in equation (10) in blue. As noted by [Fama and MacBeth \(1973\)](#) the realizations of these slope coefficients have a portfolio interpretation, here labeled as the ‘Covid-19 return factor’. These implied portfolio returns are accumulated since beginning of the year. The red line represents cumulative returns to the market portfolio during this period.

Figure 10: COVID-19 factor: portfolio composition (NAICS 2-digit Industry)



The figure the loadings of our 'Covid-19 return factor' on broad industry sectors (defined at the 2-digit NAICS level). See Appendix Table [A.2](#) for portfolio weights at a more detailed industry classification.

Figure 11: Revenue forecast revisions and Covid-19 work exposure over time

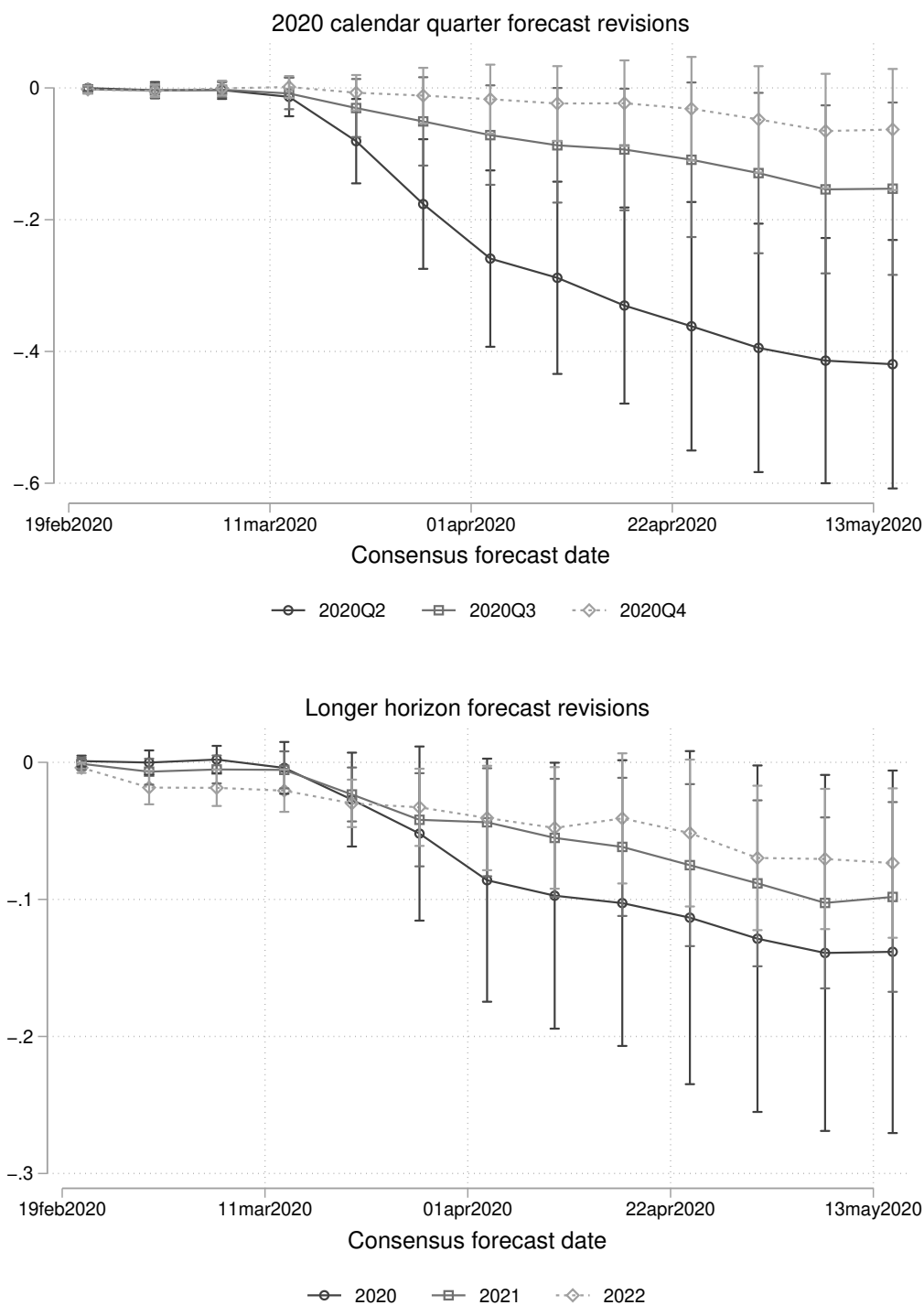


Figure plots the Fama-McBeth slope coefficients of a regression of forecast revisions on the (non-critical) industry's Covid-19 work exposure at a weekly frequency. The top panel of this figure plots the slope coefficient for revisions in revenue forecasts for Q2–Q4 2020. The bottom panel plots the corresponding revisions for the years 2020 through 2020.

Figure 12: Default Probabilities and Covid-19 work exposure over time

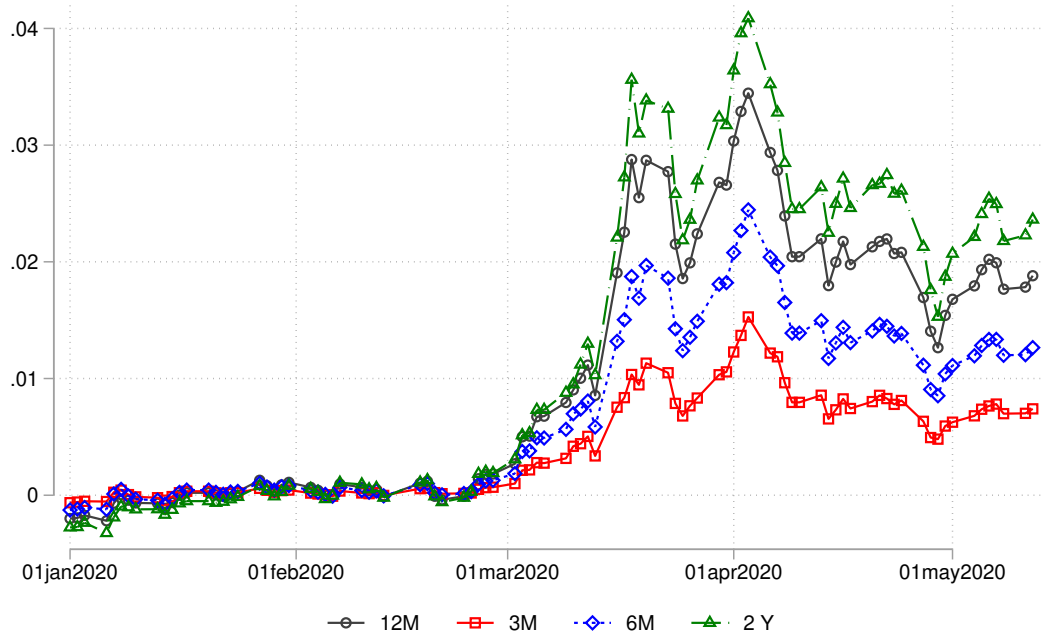


Figure plots the Fama-McBeth slope coefficients of a regression of default probabilities on the (non-critical) industry's Covid-19 work exposure at a weekly frequency. Different colors correspond to different forecast horizons.

Table 1: Firm summary statistics by quartiles of Covid-19 work exposure

Firm characteristic (median)	A. All industries				B. Firms in non-critical industries			
	Covid work exposure bin:				Covid work exposure bin:			
	Lowest	2	3	Highest	Lowest	2	3	Highest
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Covid-19 work exposure	0.45	0.64	0.82	0.98	0.38	0.69	0.86	0.98
Sales (\$ M)	41	465	1,280	1,479	423	919	1,300	1,241
Employment (thousands)	0.18	1.14	2.57	4.80	1.50	1.25	4.50	4.32
Market capitalization (\$ M)	762	933	2,008	1,573	1,731	1,239	1,519	1,282
Tobin's Q	2.69	1.76	1.43	1.37	2.09	1.47	1.55	1.34
Book Debt to Book Assets	40.7	52.7	56.9	61.1	53.3	52.9	55.2	60.9
R&D / Sales	31.2	8.7	2.1	0.1	15.4	5.9	2.2	0.6
SG&A / Sales	60.7	32.5	19.7	15.7	47.4	19.7	20.8	15.7
PPE to Assets	12.2	25.2	53.0	62.2	16.5	42.3	36.0	61.3
Gross Profitability to Assets	11.7	29.7	23.6	23.4	34.5	22.1	29.6	23.9
Return on assets (ROA)	-19.2	7.8	10.5	11.2	6.2	9.6	10.7	11.5

Table reports median characteristics of firms in the Compustat database, grouped into quartiles based on our industry-based measure of Covid-19 work exposure. The left panel (A) summarizes these characteristics for all firms, including those in critical industries. The right panel (B) repeats the analysis for the subsample of firms which we classify as non-critical. The list of critical industries at the 4-digit NAICS level is in Appendix Table [A.1](#). Gross profitability is sales (Compustat: sale) minus costs of goods sold (Compustat: cogs); Tobin's Q is computed as the sum of the book value of assets (Compustat: at) plus the market value of equity (Compustat: prcc.f times csho) minus the book value of equity (Compustat: ceq) minus deferred taxes (Compustat: txdb). PPE is Property Plant and Equipment (Compustat: ppegt).

Table 2: Covid-19 Work Exposure and Employment Growth

A. Month-on-month growth

	Weighted by Mar'20 employment		Equal weighted	
	All Industries (1)	Non-Critical Only (2)	All Industries (3)	Non-Critical Only (4)
Covid-19 Work Exposure	-0.619** (-2.39)	-1.018*** (-3.23)	-0.347*** (-3.30)	-0.476*** (-3.30)
N	73	52	73	52
R^2	0.151	0.317	0.079	0.135

B. Year-on-year growth

	Weighted by Mar'19 employment		Equal weighted	
	All Industries (5)	Non-Critical Only (6)	All Industries (7)	Non-Critical Only (8)
Covid-19 Work Exposure	-0.642** (-2.37)	-1.057*** (-3.25)	-0.360*** (-3.28)	-0.514*** (-3.47)
Observations	73	52	73	52
R^2	0.149	0.315	0.076	0.142

Table reports the coefficients estimates from equation (3) in the document using employment-weighted and unweighted specifications. Odd-numbered columns repeat the analysis for the subsample of non-critical industries. The dependent variable is constructed using private sector employment data from the BLS' April 2020 employment report at the 3-digit NAICS level. Standard errors are robust to heteroskedasticity (White, 1980). The list of critical industries at the 4-digit NAICS level is in Appendix Table A.1. We classify a 3-digit NAICS industry as critical if at least 50% of its employment is classified as critical based on our more disaggregated measure.

Table 3: Covid-19 Work Exposure and Worker Employment Outcomes

Worker is not employed as of... (conditional on being employed as of March 2020)	April 2020			February 2020
	(1)	(2)	(3)	(4)
Critical industry	-0.0922*** (-4.87)	-0.0916*** (-5.32)	-0.0813*** (-5.01)	-0.00224 (-0.63)
Non-critical industry \times Covid-19 work exposure	0.506*** (6.28)	0.408*** (5.24)	0.360*** (4.77)	-0.00889 (-0.59)
Critical industry \times Covid-19 work exposure	0.284*** (3.22)	0.181** (2.11)	0.108 (1.43)	-0.0414 (-1.56)
<i>Controls</i>				
College Graduate Dummy		-0.0635*** (-5.34)	-0.0380*** (-3.27)	-0.00423 (-0.88)
Female Dummy		0.0459*** (3.14)	0.0315** (2.16)	0.0146*** (2.83)
Kids under 14		-0.0226* (-1.65)	-0.0171 (-1.30)	-0.000559 (-0.08)
Female Dummy \times Kids under 14		0.0401** (2.24)	0.0279 (1.58)	-0.00408 (-0.56)
College Graduate Dummy \times Kids under 14		-0.00130 (-0.09)	0.00638 (0.45)	-0.00731 (-0.94)
Age 30 to 39		-0.0247* (-1.79)	-0.00746 (-0.56)	-0.00503 (-0.50)
Age 40 to 49		-0.0341*** (-2.79)	-0.0117 (-0.90)	-0.00473 (-0.56)
Age 50+		-0.0268** (-2.23)	-0.00233 (-0.19)	-0.00671 (-0.82)
2019 earnings in bottom quartile			0.125*** (6.88)	0.0184*** (3.53)
2019 earnings in 2nd quartile			0.0625*** (4.76)	0.00462 (1.20)
2019 earnings in 3rd quartile			0.0204*** (2.87)	0.00145 (0.49)
Firm size: Under 10			0.0239 (1.27)	0.00496 (0.71)
Firm size: 10 to 99			0.00951 (0.58)	-0.00282 (-0.63)
Firm size: 100 to 999			-0.00790 (-0.74)	0.00130 (0.23)
Constant	0.179*** (10.19)	0.205*** (10.09)	0.121*** (6.20)	0.0135 (1.53)
Observations	9,660	9,273	9,273	6,193
R^2	0.040	0.056	0.075	0.010

Table reports the coefficients estimates from equation (4) in the document. Standard errors are double-clustered based on occupation and industry. The dependent variable is an indicator which equals one if an individual does not have a job in April (columns 1-3) or February (column 4) 2020. To be included in the sample, workers need to appear in the March 2020 CPS and March 2019 ASEC survey, and either the April and/or February core CPS sample. The list of critical industries at the 4 digit NAICS level is in Appendix Table A.1. We crosswalk the NAICS-based classification to CPS industry codes and define critical Census industries as those for which at least 50% of employment is associated with critical NAICS industries. The cross-sectional standard deviation of the exposure measure for workers in our sample is 12.4%.

Table 4: Covid-19 Work Exposure, Stock Returns and Analyst Forecasts

	Stock	Analyst Forecast Revisions					
	Returns	2020Q2	2020Q3	2020Q4	2020	2021	2022
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Covid-19 Work Exposure	-0.375*** (-5.16)	-0.419*** (-4.34)	-0.155** (-2.30)	-0.067 (-1.43)	-0.138** (-2.03)	-0.103*** (-2.99)	-0.074** (-2.62)
Observations	148	132	133	133	134	133	98
R^2	0.264	0.213	0.078	0.029	0.064	0.095	0.082

Table plots the coefficients estimates from equations (9) and (7) in the document for non-critical industries, where the dependent variables are constructed using firm data from Compustat and Capital IQ, aggregated to the 4-digit NAICS level. The regression is weighted by total Compustat 2019 employment in each industry. Standard errors are robust to heteroskedasticity (White, 1980). The list of critical industries is in Appendix Table A.1.

Table 5: Covid-19 Work Exposure and Default Probabilities

	Change in probability of default in next			
	3 months	6 months	12 months	24 months
	(1)	(2)	(3)	(4)
Covid-19 Work Exposure	0.007* (2.42)	0.013** (2.86)	0.019*** (3.41)	0.024*** (3.96)
Observations	163	163	163	163
R^2	0.147	0.187	0.222	0.222

Table plots the coefficients estimates from equation (8) in the document for non-critical industries, where the dependent variables are constructed using firm data from Compustat and the RMI Credit Research Database, aggregated to the 4-digit NAICS level. The regression is weighted by total Compustat 2019 employment in each industry. Standard errors are robust to heteroskedasticity (White, 1980). The list of critical industries is in Appendix Table A.1.

Appendix Tables and Figures

Table A.1: List of Critical Industries

NAICS Code	Industry Name
1111	Oilseed and Grain Farming
1112	Vegetable and Melon Farming
1113	Fruit and Tree Nut Farming
1119	Other Crop Farming
1121	Cattle Ranching and Farming
1122	Hog and Pig Farming
1123	Poultry and Egg Production
1124	Sheep and Goat Farming
1129	Other Animal Production
1141	Fishing
1142	Hunting and Trapping
1151	Support Activities for Crop Production
1152	Support Activities for Animal Production
2211	Electric Power Generation, Transmission and Distribution
2212	Natural Gas Distribution
2213	Water, Sewage and Other Systems
3111	Animal Food Manufacturing
3112	Grain and Oilseed Milling
3113	Sugar and Confectionery Product Manufacturing
3114	Fruit and Vegetable Preserving and Specialty Food Manufacturing
3115	Dairy Product Manufacturing
3116	Animal Slaughtering and Processing
3117	Seafood Product Preparation and Packaging
3118	Bakeries and Tortilla Manufacturing
3119	Other Food Manufacturing
3121	Beverage Manufacturing
3254	Pharmaceutical and Medicine Manufacturing
3256	Soap, Cleaning Compound, and Toilet Preparation Manufacturing
3312	Steel Product Manufacturing from Purchased Steel
3391	Medical Equipment and Supplies Manufacturing
4242	Drugs and Druggists' Sundries Merchant Wholesalers
4245	Farm Product Raw Material Wholesalers
4413	Automotive Parts, Accessories, and Tire Stores
4441	Building Material and Supplies Dealers
4451	Grocery Stores
4452	Specialty Food Stores
4453	Beer, Wine, and Liquor Stores

Table A.1: List of Critical Industries (cont)

NAICS Code	Industry Name
4461	Health and Personal Care Stores
4471	Gasoline Stations
4523	General Merchandise Stores, including Warehouse Clubs and Supercenters
4539	Other Miscellaneous Store Retailers
4541	Electronic Shopping and Mail-Order Houses
4812	Nonscheduled Air Transportation
4841	General Freight Trucking
4842	Specialized Freight Trucking
4851	Urban Transit Systems
4852	Interurban and Rural Bus Transportation
4853	Taxi and Limousine Service
4859	Other Transit and Ground Passenger Transportation
4861	Pipeline Transportation of Crude Oil
4862	Pipeline Transportation of Natural Gas
4885	Freight Transportation Arrangement
4911	Postal Service
4921	Couriers and Express Delivery Services
4922	Local Messengers and Local Delivery
4931	Warehousing and Storage
5173	Telecommunications Resellers
5179	Other Telecommunications
5211	Monetary Authorities-Central Bank
5221	Depository Credit Intermediation
5222	Nondepository Credit Intermediation
5223	Activities Related to Credit Intermediation
5231	Securities and Commodity Contracts Intermediation and Brokerage
5232	Securities and Commodity Exchanges
5239	Other Financial Investment Activities
5241	Insurance Carriers
5242	Agencies, Brokerages, and Other Insurance Related Activities
5251	Insurance and Employee Benefit Funds
5259	Other Investment Pools and Funds
5411	Legal Services
5412	Accounting, Tax Preparation, Bookkeeping, and Payroll Services
5621	Waste Collection
5622	Waste Treatment and Disposal
5629	Remediation and Other Waste Management Services
6111	Elementary and Secondary Schools
6211	Offices of Physicians

Table A.1: List of Critical Industries (cont)

NAICS Code	Industry Name
6214	Outpatient Care Centers
6215	Medical and Diagnostic Laboratories
6216	Home Health Care Services
6219	Other Ambulatory Health Care Services
6221	General Medical and Surgical Hospitals
6223	Specialty (except Psychiatric and Substance Abuse) Hospitals
6231	Nursing Care Facilities (Skilled Nursing Facilities)
6233	Continuing Care Retirement Communities and Assisted Living Facilities for the Elderly
9211	Executive, Legislative, and Other General Government Support
9221	Justice, Public Order, and Safety Activities
9231	Administration of Human Resource Programs
9241	Administration of Environmental Quality Programs
9251	Administration of Housing Programs, Urban Planning, and Community Development
9261	Administration of Economic Programs
9271	Space Research and Technology
9281	National Security and International Affairs

Table A.2: Covid-19 Factor, portfolio weights (4-Digit NAICS)

Industry (NAICS)	Portfolio Weight (%)
4481: Clothing Stores	18.72
5613: Employment Services	15.04
7225: Restaurants and Other Eating Places	13.94
7211: Traveler Accommodation	10.63
4811: Scheduled Air Transportation	10.55
5151: Radio and Television Broadcasting	7.82
4522: Department Stores	7.69
7223: Special Food Services	5.71
3331: Agriculture, Construction, and Mining Machinery Manufacturing	5.43
4831: Deep Sea, Coastal, and Great Lakes Water Transportation	5.32
3363: Motor Vehicle Parts Manufacturing	5.24
3361: Motor Vehicle Manufacturing	5.17
3344: Semiconductor and Other Electronic Component Manufacturing	3.94
3329: Other Fabricated Metal Product Manufacturing	3.49
4411: Automobile Dealers	2.90
7131: Amusement Parks and Arcades	2.63
3339: Other General Purpose Machinery Manufacturing	2.56
3221: Pulp, Paper, and Paperboard Mills	2.54
5617: Services to Buildings and Dwellings	2.30
4244: Grocery and Related Product Merchant Wholesalers	2.15
3261: Plastics Product Manufacturing	2.13
5121: Motion Picture and Video Industries	2.01
3262: Rubber Product Manufacturing	1.92
4511: Sporting Goods, Hobby, and Musical Instrument Stores	1.80
3222: Converted Paper Product Manufacturing	1.79
3311: Iron and Steel Mills and Ferroalloy Manufacturing	1.79
2382: Building Equipment Contractors	1.55
2371: Utility System Construction	1.52
3252: Artificial and Synthetic Fibers and Filaments Manufacturing	1.37
5616: Investigation and Security Services	1.37
3219: Other Wood Product Manufacturing	1.34
3353: Electrical Equipment Manufacturing	1.23
4482: Shoe Stores	1.22
4431: Electronics and Appliance Stores	1.21
4231: Motor Vehicle and Motor Vehicle Parts and Supplies Merchant Wholesalers	1.16
7132: Gambling Industries	1.14
7139: Other Amusement and Recreation Industries	1.09
3141: Textile Furnishings Mills	1.07
3399: Other Miscellaneous Manufacturing	1.06

Table A.2: Covid-19 Factor, portfolio weights (cont)

Industry (NAICS)	Portfolio Weight (%)
2362: Nonresidential Building Construction	1.05
8123: Drycleaning and Laundry Services	0.98
3324: Boiler, Tank, and Shipping Container Manufacturing	0.95
2379: Other Heavy and Civil Engineering Construction	0.94
4236: Electrical and Electronic Goods Merchant Wholesalers	0.94
3152: Cut and Sew Apparel Manufacturing	0.94
5152: Cable and Other Subscription Programming	0.92
2361: Residential Building Construction	0.90
4532: Office Supplies, Stationery, and Gift Store	0.90
3359: Other Electrical Equipment and Component Manufacturing	0.86
2123: Nonmetallic Mineral Mining and Quarrying	0.85
3334: Refrigeration Equipment Manufacturing	0.84
3366: Ship and Boat Building	0.83
3272: Glass and Glass Product Manufacturing	0.76
3323: Architectural and Structural Metals Manufacturing	0.72
8121: Personal Care Services	0.70
3231: Printing and Related Support Activities	0.69
6222: Psychiatric and Substance Abuse Hospitals	0.68
3322: Cutlery and Handtool Manufacturing	0.66
4422: Home Furnishings Stores	0.65
5611: Office Administrative Services	0.64
3362: Motor Vehicle Body and Trailer Manufacturing	0.62
3352: Household Appliance Manufacturing	0.61
5615: Travel Arrangement and Reservation Services	0.58
2121: Coal Mining	0.58
7113: Promoters of Performing Arts, Sports, and Similar Events	0.58
6244: Child Day Care Services	0.58
3332: Industrial Machinery Manufacturing	0.56
3279: Other Nonmetallic Mineral Product Manufacturing	0.50
3251: Basic Chemical Manufacturing	0.47
3371: Household and Institutional Furniture and Kitchen Cabinet Manufacturing	0.47
3169: Other Leather and Allied Product Manufacturing	0.45
3369: Other Transportation Equipment Manufacturing	0.43
3313: Alumina and Aluminum Production and Processing	0.42
3325: Hardware Manufacturing	0.39
5614: Business Support Services	0.35
3372: Office Furniture (including Fixtures) Manufacturing	0.33
4483: Jewelry, Luggage, and Leather Goods Stores	0.32
2383: Building Finishing Contractors	0.31

Table A.2: Covid-19 Factor, portfolio weights (cont)

Industry (NAICS)	Portfolio Weight (%)
3379: Other Furniture Related Product Manufacturing	0.31
4237: Hardware, and Plumbing and Heating Equipment and Supplies Merchant Wholesalers	0.30
7111: Performing Arts Companies	0.29
3351: Electric Lighting Equipment Manufacturing	0.26
8129: Other Personal Services	0.24
5619: Other Support Services	0.22
3212: Veneer, Plywood, and Engineered Wood Product Manufacturing	0.21
3321: Forging and Stamping	0.17
3273: Cement and Concrete Product Manufacturing	0.17
4238: Machinery, Equipment, and Supplies Merchant Wholesalers	0.17
3326: Spring and Wire Product Manufacturing	0.14
2373: Highway, Street, and Bridge Construction	0.14
3132: Fabric Mills	0.14
6116: Other Schools and Instruction	0.14
4512: Book Stores and News Dealers	0.13
4412: Other Motor Vehicle Dealers	0.13
4832: Inland Water Transportation	0.13
4883: Support Activities for Water Transportation	0.09
3259: Other Chemical Product and Preparation Manufacturing	0.08
4421: Furniture Stores	0.08
5612: Facilities Support Services	0.07
3274: Lime and Gypsum Product Manufacturing	0.07
4881: Support Activities for Air Transportation	0.06
7224: Drinking Places (Alcoholic Beverages)	0.05
4869: Other Pipeline Transportation	0.04
4543: Direct Selling Establishment	0.04
2372: Land Subdivision	0.03
3211: Sawmills and Wood Preservation	0.03
6213: Offices of Other Health Practitioners	0.03
3335: Metalworking Machinery Manufacturing	0.02
4889: Other Support Activities for Transportation	0.01
4243: Apparel, Piece Goods, and Notions Merchant Wholesalers	0.01
4247: Petroleum and Petroleum Products Merchant Wholesalers	0.01
3327: Machine Shops; Turned Product; and Screw, Nut, and Bolt Manufacturing	0.00
4442: Lawn and Garden Equipment and Supplies Stores	0.00
7114: Agents and Managers for Artists, Athletes, Entertainers, and Other Public Figures	0.00
8111: Automotive Repair and Maintenance	0.00
7112: Spectator Sports	0.00
4239: Miscellaneous Durable Goods Merchant Wholesalers	-0.01

Table A.2: Covid-19 Factor, portfolio weights (cont)

Industry (NAICS)	Portfolio Weight (%)
5174: Satellite Telecommunications	-0.05
4251: Wholesale Electronic Markets and Agents and Brokers	-0.09
4241: Paper and Paper Product Merchant Wholesalers	-0.09
8122: Death Care Services	-0.10
5414: Specialized Design Services	-0.10
2111: Oil and Gas Extraction	-0.18
4246: Chemical and Allied Products Merchant Wholesalers	-0.24
3343: Audio and Video Equipment Manufacturing	-0.29
4233: Lumber and Other Construction Materials Merchant Wholesalers	-0.40
5419: Other Professional, Scientific, and Technical Services	-0.50
3333: Commercial and Service Industry Machinery Manufacturing	-0.54
4249: Miscellaneous Nondurable Goods Merchant Wholesalers	-0.56
5111: Newspaper, Periodical, Book, and Directory Publishers	-0.62
5418: Advertising, Public Relations, and Related Services	-1.08
3241: Petroleum and Coal Products Manufacturing	-1.14
3336: Engine, Turbine, and Power Transmission Equipment Manufacturing	-1.33
5413: Architectural, Engineering, and Related Services	-1.93
5416: Management, Scientific, and Technical Consulting Services	-2.32
3255: Paint, Coating, and Adhesive Manufacturing	-2.68
5417: Scientific Research and Development Services	-2.89
4234: Professional and Commercial Equipment and Supplies Merchant Wholesalers	-3.18
3365: Railroad Rolling Stock Manufacturing	-3.39
2131: Support Activities for Mining	-4.11
3341: Computer and Peripheral Equipment Manufacturing	-5.71
3345: Navigational, Measuring, Electromedical, and Control Instruments Manufacturing	-9.75
3342: Communications Equipment Manufacturing	-10.32
3364: Aerospace Product and Parts Manufacturing	-14.68
5112: Software Publishers	-16.67
5415: Computer Systems Design and Related Services	-31.04
5182: Data Processing, Hosting, and Related Services	-34.77
5191: Other Information Services	-40.74